ANTIETAM NATIONAL BATTLEFIELD,

MARYLAND

WATER RESOURCES SCOPING REPORT

Don P. Weeks

Technical Report NPS/NRWRD/NRTR-2002/299

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NATIONAL PARK SERVICE
DEPARTMENT OF THE INTERIOR

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United States Department of the Interior
National Park Service

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EXECUTIVE SUMMARY

On September 17, 1862, 40,000 Confederates fought against 87,000 Union troops along Antietam Creek just outside of Sharpsburg, Maryland. At the end of the day over 23,000 men were dead, wounded, or missing…the single bloodiest day of the American Civil War. The farms and farmlands where this battle took place have been preserved by the National Park Service to freeze this moment in time for visitors to experience. Antietam National Battlefield (ANTI) was created to preserve this historic site and interpret the civil war battle. The water-related resources of this battlefield are an integral component of the historical context of the site and its cultural landscape. Today's challenge for ANTI management is to establish a balance in preserving both the cultural and natural resources of the battlefield.

This Water Resources Scoping Report is being provided at the request of ANTI to assemble information pertaining to the park's water resources. This report identifies and briefly describes the natural resources at ANTI and some of the water-related issues that park management should address.

For ANTI, several water-related issues exist. Many of the issues presented in this report center around the lack of basic information (i.e., baseline data) that would better assist the NPS's understanding of the park's water resources. Thus, the NPS may be unaware of significant and/or time-sensitive issues because the natural resource information is not available.

The contents of this report are limited to information made available to the author during the time this report was prepared. Where appropriate, issue-specific recommendation(s) previously proposed by NPS management via ANTI planning documents (i.e., RMP) are included. As a result, descriptions of the natural resources and water resource issues vary in detail, and inclusion of issue-related recommendations is inconsistent.

As part of the effort by the NPS Water Resources Division (WRD) to produce this report for ANTI, WRD staff traveled to the park in December 2001. The purposes of this travel were to: 1) introduce elements of the WRSR effort to ANTI, 2) become familiar with the water resources and high priority water-related issues at the park, and 3) obtain pertinent information from park files. The high-priority issues identified at ANTI during this effort include:

- Baseline Inventory and Monitoring
- Riparian Restoration
- Agricultural Management
- Wastewater Treatment
- Groundwater Wells and Springs
- Hazardous Waste Management and Spill Contingency Planning
- Wetlands Management
- Coordination

Each of these issues has aspects that affect the park's water resources, though some may not be under NPS control; therefore, it is important to recognize the fact that multi-agency communication and coordination are essential to successfully manage ANTI's watershed. The park is encouraged to use components of this scoping report, and build from the recommendations provided, to develop time-sensitive management strategies and project statements related to park-specific water resource issues.

INTRODUCTION

Antietam National Battlefield (ANTI) is the location of the single bloodiest day of the American Civil War. The Battle of Antietam began at dawn on September 17, 1862. About 40,000 Southerners under the command of General Robert E. Lee fought against 87,000 troops of the Federal Army of the Potomac commanded by General George McClellan. At the end of the day, 23,110 men were dead, wounded, or missing. ANTI today is considered one of the best preserved Civil War areas in the national park system. The farms and farmlands in and near the national battlefield appear much as they did on the eve of the 1862 battle.

Equally important to ANTI's cultural significance are the park's 3,256 acres of natural resources. Visitors come to experience the historical battle, while also enjoying the natural setting. Along with an informative visitor center and driving tour of the battlefield, ANTI offers a beautiful landscape of forest, rolling hills, springs, and streams for visitors to experience through hiking, camping, floating, and biking. Today's challenge for ANTI management is to establish a healthy balance in preserving both the parks' cultural and natural resources.

This report provides some foundation toward a better understanding of ANTI's natural resources. The objective of this report is to present NPS management with a brief overview of the battlefield's aquatic environments, existing water-related information, and issues that pertain to ANTI, while also identifying some of the "information needs" that will better assist the park in providing a greater level of water resource protection. At the end of the report, an evaluation of this information is presented to determine if a more comprehensive Water Resources Management Plan (WRMP) is warranted for this NPS unit.

The initial information-gathering effort for this report included a 2-day visit by the author to ANTI in December 2001. Information was derived from many sources, including interviews with park staff and review of existing natural resources information with emphasis on water resources. The author was also fortunate to visit many of the sites in ANTI (i.e., Miller Spring, Mumma Spring, Antietam Creek, etc.), which provided a better appreciation of the water resources and associated issues.

Location, Demography, Legislation, and Management

ANTI is located in Washington County, Maryland, 13 miles south of Hagerstown (Figure 1). Washington County grew by 9 percent between 1970 and 1980 (National Park Service, 1992). The 2000 county population was 128,300 and is projected to grow to more than 140,000 by year 2020. The county enjoys a high employment rate and moderate incomes, with a much lower cost of living than the nearby metropolitan neighbors (Hagerstown-Washington County Economic Development Commission, 2001). Sharpsburg, Maryland, which is immediately west of the battlefield, has approximately 800 residents and retains much of its historic character. The lands surrounding Sharpsburg are primarily low-density residential, rural and agricultural.

Figure 1. Regional Map, Antietam National Battlefield

ANTI includes 1,747.42 acres in federal ownership, 1,002.40 acres privately owned with scenic easements held by the federal government, and 506.07 acres in private ownership, for a total of 3,255.89 acres (Figure 2).

The National Battlefield was established by Congress in 1890. ANTI was created for the purpose of "surveying, locating and preserving the lines of battle for the Army of the Potomac and of the Army of Northern Virginia at Antietam and for marking the same…" (Snell and Brown, 1986). In 1960, Congress established Public Law 86-438 to further define the park's preservation mandate and mission, which directed the NPS:

> "to preserve, protect and improve the Antietam Battlefield comprising approximately 1,800 acres in the State of Maryland and the property of the United States thereon, to assure the public a full and unimpeded view thereof, and to provide for the maintenance of the site (other than those portions thereof that are occupied by public buildings and monuments and the Antietam National Cemetery) in, or its restoration to, substantially the condition in which it was at the time of the battle of Antietam" (National Park Service, 1992).

ANTI's 1995 Resources Management Plan states the following management objective for the park's landscape:

> The Antietam National Battlefield will be managed to provide for the restoration and preservation of the battlefield landscape to substantially the condition in which it was on the eve of the Battle of Antietam. The preserved battlefield will

Figure 2. Antietam National Battlefield, Maryland

> include within a natural setting those essential features of the rural agricultural landscape (cultural landscape) which existed at the time (e.g., orchards, fences, field patterns, woods), remaining historic structures and resources, and those post-battle elements necessary for the administration, commemoration and visitor understanding of the battle (e.g., monuments, visitor and administrative structures and facilities, roads) (Kemble and Wenschhof, 1995).

Some additional legislation and executive orders that help guide management of ANTI's aquatic resources include the following:

> The *National Park Service Organic Act* of 1916 established the NPS and mandated that it "shall promote and regulate the use of the federal areas known as national parks, monuments, and reservations by such means and measures as conform to the fundamental purpose of the said parks, monuments, and reservations, which purpose is to conserve the scenery and the natural and historic objects and the wildlife therein and to provide for the enjoyment of future generations."
>
> The *General Authorities Act* of 1970 reinforced the 1916 *Organic Act* – all park lands are united by a common preservation purpose, regardless of title or designation. Hence, federal law protects all water resources in the national park system equally, and it is the fundamental duty of the NPS to protect those resources unless otherwise indicated by Congress.
>
> The *Redwood National Park Act* (1978) amended the *General Authorities Act* of 1970 to mandate that all park system units be managed and protected "in light of the high public value and integrity of the national park system." Furthermore, no activities should be undertaken "in derogation of the values and purposes for which these various areas have been established", except where specifically authorized by law or as may have been or shall be directly and specifically provided for by Congress.
>
> The *National Parks Omnibus Management Act* of 1998 attempts to improve the ability of the NPS to provide state-of-the-art management, protection, and interpretation of and research on the resources of the national park system by:
>
> - Assuring that management of units of the national park system is enhanced by the availability and utilization of a broad program of the highest quality science and information;
> - Authorizing the establishment of cooperative agreements with colleges and universities, including but not limited to land grant schools, in partnership with other Federal and State agencies, to establish cooperative study units to conduct multi-disciplinary research and develop integrated information products on the resources of the national park system, or of the larger region of which parks are a part;

- Undertaking a program of inventory and monitoring of national park system resources to establish baseline information and to provide information on the long-term trends in the condition of national park system resources, and;
- Taking such measures as are necessary to assure the full and proper utilization of the results of scientific study for park management decisions. In each case in which an action undertaken by the NPS may cause a significant adverse effect on a park resource, the administrative record shall reflect the manner in which unit resource studies have been considered. The trend in the condition of resources of the national park system shall be a significant factor in the annual performance.

Congress passed the *National Environmental Policy Act* (NEPA) in 1969, which requires that federal actions which may have significant environmental impacts shall: "utilize a systematic, interdisciplinary approach which will insure the integrated use of the natural and social sciences and the environmental design arts in planning and in decision making which may have an impact on man's environment."

The *Clean Air Act* of 1970 (as amended) regulates airborne emissions of a variety of pollutants from area, stationary, and mobile sources. The 1990 amendments to this act were intended primarily to fill the gaps in the earlier regulations, such as acid rain, ground level ozone, stratospheric ozone depletion and air toxics. The amendments identify a list of 189 hazardous air pollutants. The U.S. Environmental Protection Agency must study these chemicals, identify their sources, determine if emissions standards are warranted, and promulgate appropriate regulations.

The 1972 *Federal Water Pollution Control Act*, more commonly known as the *Clean Water Act*, was designed to restore and maintain the integrity of the nation's waters. States implement the protection of water quality under the authority granted by the Clean Water Act through best management practices and through water quality standards. Section 404 of the act requires that a permit be issued for discharge of dredged or fill materials in waters of the United States, including wetlands. The U.S. Army Corps of Engineers administers the Section 404 permit program. Section 402 of the act requires that a National Pollutant Discharge Elimination System (NPDES) permit be obtained for the discharge of pollutants from any point source into the waters of the United States. In general, all discharges and storm water runoff from major industrial and transportation activities, municipalities, and certain construction activities must be permitted by the NPDES program. The U.S. Environmental Protection Agency usually delegates NPDES permitting authority to the state.

The *Endangered Species Act* of 1973 requires the NPS to identify and promote the conservation of all federally listed endangered, threatened, or candidate species within any park unit boundary. This act requires all entities using federal funding to consult with the Secretary of Interior on activities that potentially impact endangered flora and fauna. It requires agencies to protect endangered and threatened species as well as designated critical habitats. While not required by legislation, it is NPS policy to also identify state and locally listed species of concern and support the preservation and restoration of those species and their habitats.

Executive Order 13112: *Invasive Species* complements and builds upon existing federal authority to aid in the prevention and control of invasive species.

Executive Order 11990: *Wetlands Protection* directs the NPS to 1) provide leadership and to take action to minimize the destruction, loss, or degradation of wetlands; 2) preserve and enhance the natural and beneficial values of wetlands; and 3) to avoid direct or indirect support of new construction in wetlands unless there are no practicable alternative to such construction and the proposed action includes all practicable measures to minimize harm to wetlands.

Executive Order 11988: *Floodplain Management.* The objective of the E.O. is, "…to avoid to the extent possible the long- and short-term adverse impacts associated with the occupancy and modification of floodplains and to avoid direct and indirect support of floodplain development wherever there is an practicable alternative." For non-repetitive actions, the E.O. states that all proposed facilities must be located outside the limits of the 100-year floodplain. If there were no practicable alternative to construction within the floodplain, adverse impacts would be minimized during the design of the project.

Director's Order #2: Park Planning provides the policies and guidance related to park planning. The Park Service has a mandate in its Organic Act and other legislation to preserve resources unimpaired for the enjoyment of future generations. NPS park planning will help define what types of resource conditions, visitor uses, and management actions will best achieve that mandate. The NPS is to maintain an up-to-date General Management Plan (GMP) for each unit of the national park system. The purpose of the plan is to ensure that each park has a clearly defined direction for natural and cultural resource preservation and visitor use. ANTI completed a GMP in 1992. A park's Resources Management Plan (RMP) describes the specific management actions needed to protect and manage the park's natural and cultural resources. ANTI's 1995 RMP identifies existing resources and conditions, present actions, and identifies future needs consistent with legislative and administrative guidance, resource significance, and other park planning documents. Discipline-specific planning documents that complement the RMP (e.g., Fire Management Plan, Water Resources Scoping Report, etc.) are prepared for NPS units when warranted.

Chesapeake Bay Program: Through a 1993 Memorandum of Understanding with the EPA, the National Park Service became a formal partner in the Chesapeake Bay Program. As a partner, the Park Service contributes to the restoration, interpretation, and conservation of the Chesapeake Bay's many valuable resources---both within the national parks of its watershed, including ANTI, and in coordination with others striving for the

Bay's continued recovery. Through the 1994 Agreement of Federal Agencies on Ecosystem Management in the Chesapeake Bay, the Federal partners have built a solid record of measurable accomplishments. The 1998 Federal Agencies Chesapeake Ecosystem Unified Plan provides a timely response to the new watershed management initiatives identified within the President's Clean Water Action Plan and keeps the Chesapeake Bay Program on the cutting edge of ecosystem management nationally. Congress reauthorized the Chesapeake Bay Program with the passage of *the Chesapeake Bay Restoration Act of 2000*. This agreement strengthens existing goals and adds some new commitments to the collaborative effort. The underlying goal is to have the waters of the Chesapeake Bay and its tributaries meet the Clean Water Act standards by 2010. Many of the initiatives are well underway within national parks and program centers in response to established policy and mandates; others challenge the National Park Service to increase a commitment to partnerships, resources management, and ecosystem management within the Chesapeake Bay watershed.

DESCRIPTION OF NATURAL RESOURCES

Climate

The climate of ANTI is typical of the mid-Atlantic states; temperate and humid. Moderate precipitation dominates the Potomac River Basin. The area is influenced by prevailing westerly winds, which are frequently interrupted by surges of cool northern and warm southern air masses. In the warmer half of the year, the basin is affected by showers and thunderstorms. These storms often cause flash flooding in the narrow valleys (Hobba *et al*., 1972). Most flooding events occur in either early spring due to spring rains and snow melting, or early fall during hurricane season. The last major flood event in Washington County was 1996 (Washington County-Maryland, 2001). Figure 3 presents 1961 – 1990 climate data from Martinsburg, West Virginia (13 miles west of ANTI). The annual average precipitation is 37.4 inches. On average, the area receives 29.7 inches of snow annually (Washington County-Maryland, 2001). May is the wettest month (4.1 inches) with January typically the driest month (2.3 inches). Average monthly air temperatures range from 29.7° F in January to 75.2° F in July (National Climate and Data Center, 2002).

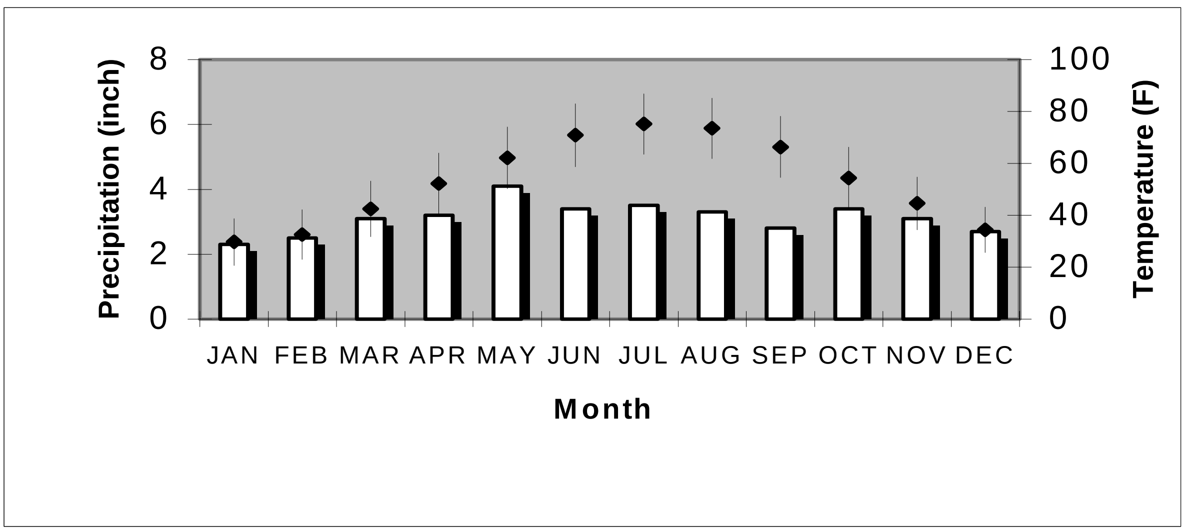


Figure 3. Monthly mean precipitation (bars) and air temperature range (diamond-whiskers) (1961-1990), Martinsburg, West Virginia (National Climate and Data Center, 2002).

Physiography

ANTI is located in the *Valley and Ridge* physiographic province (Figure 4). The *Valley and Ridge* province is characterized by elongate parallel ridges and valleys that are underlain by folded sedimentary rock. The characteristic topography of this region is the

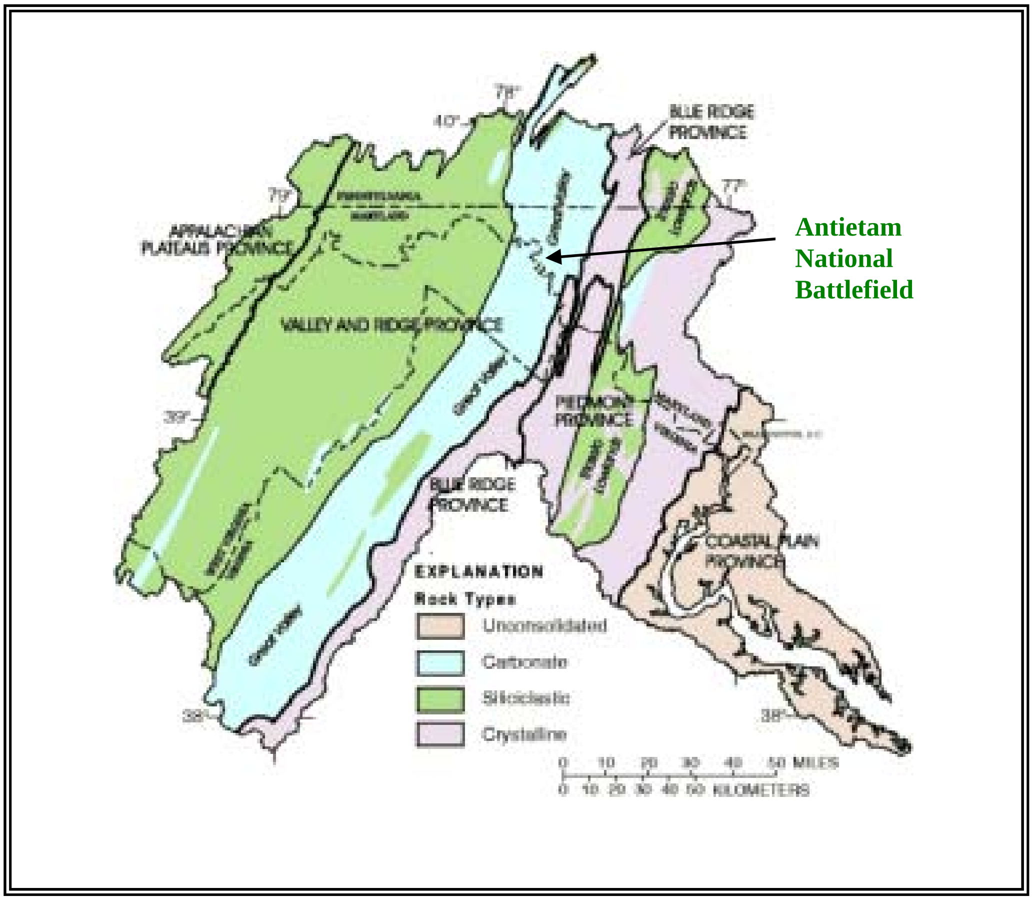


Figure 4. Generalized physiography and geology in the Potomac River Basin (modified after Ator *et al*., 1998).

result of differential weathering of linear belts of rocks. More specifically, ANTI is located in the *Great Valley*, a subprovince of the *Valley and Ridge*. The *Great Valley* is characterized by a karstic landscape where many cavern and sensitive aquatic habitats are located (William & Mary, 2000). Locally around ANTI, the *Great Valley* subprovince is referred to as the *Hagerstown Valley* of Washington County, Maryland (Duigon, 1997).

Geology

The *Valley and Ridge* province has developed on thick, folded beds of sedimentary rock deposited during the Paleozoic. The differing degrees of resistance to erosion of sandstones, shales, and carbonate rocks comprising the lithology determine local relief. In general, the more resistant sandstones cap the ridgetops, protecting the softer bedrock below from erosion. Limestones and dolomites, which underlie ANTI, form the lowlands and valleys. As shown in Figure 5, four major rock units have been mapped by the Maryland Geologic Survey in ANTI; Conococheague Limestone, Elbrook Limestone, OCc

Conococheague Limestone

Dark blue, laminated, oolitic, argillaceous and siliceous limestone, algal limestone, and flat-pebble conglomerate; siliceous shale partings; some sandstone and dolomite; thickness 1,6000 to 1,900 feet.

Ce

Elbrook Limestone

Light blue, laminated, argillaceous limestone and calcareous shale; some dolomite; thickness 1,400 to possibly 3,000 feet

Cwb

Waynesboro Formation

Upper part red, gray, and yellowish-brown, thin-bedded siltstone, shale, and ripple-marked, cross-bedded sandstone; lower part interbedded dark gray to red shale and thin-bedded dolomite; thickness approximately 600 feet.

Ct

Tomstown Dolomite

Interbedded light gray to yellowish-gray, thin- to thick-bedded dolomite and limestone; some shale layers; gradational contact with Antietam; thickness 200 to 1,000 feet.

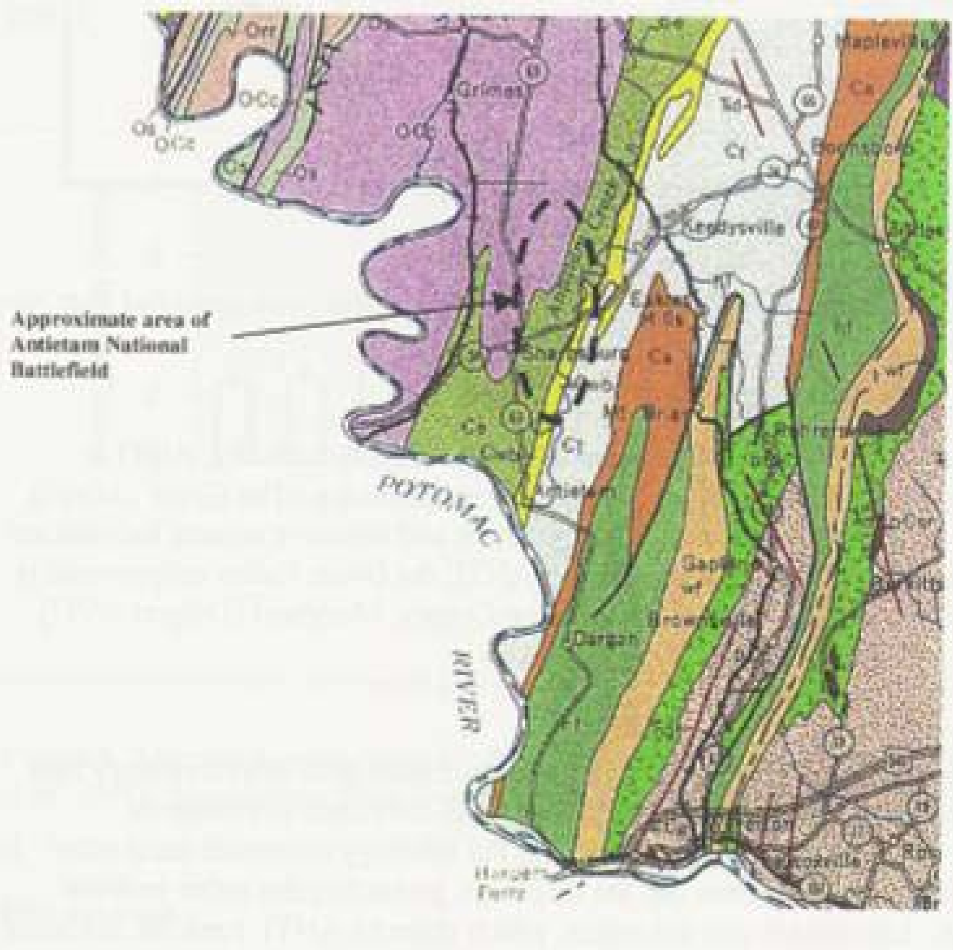


Figure 5. Geology of Antietam National Battlefield (modified after Maryland Geologic Survey, 1968).

Waynesboro Formation (siltstone, shale, sandstone, dolomite), and Tomstown Dolomite. About 89 percent of the *Hagerstown Valley* is underlain by carbonate rocks. More than 50 known caves and about 200 wells intersecting cavernous zones attest to the development of caverns in the carbonate rocks of the valley (Duigon, 2002). The NPS is required to manage ANTI's karst terrain to maintain the inherent integrity of its water quality, spring flow, drainage patterns, and caves (National Park Service, 2001). The eastern and western boundaries of the *Hagerstown Valley* are major faults separating the valley from areas having greater relief and different lithology and structure (Duigon, 2001).

Military Geology

> It was over this karst terrain that the two armies clashed. The Union forces taking up position on the far side of Antietam Creek to the east of the visitors center. The small stream valley created by the north-to-south flow of the creek is somewhat hidden from view. The Confederate forces concentrated their strength in a curved line of defense running along Hagerstown Pike to the southern end of Sharpsburg, terminating at the heights, composed of the Waynesboro Formation, overlooking Antietam Creek at the Burnside Bridge. Union forces were sent north to cross the creek at one of the several fords in open view of Lee's position, thus allowing him to shift his lines to the impending attack on his northern flank. Opening engagements came from the North Woods and the Cornfield. Later in the morning the battle shifted toward the center of Lee's line and concentrated around the Sunken Road (Bloody Lane). The four hours of fighting along Sunken Road resulted in 5,000 casualties. Union forces were unable to cross Burnside Bridge throughout most of the day due to a commanding position held by a small Confederate force of Georgians along the heights overlooking the bridge. By the time General Burnside's forces managed to cross, the element of surprise was lost. With the loss of surprise and the arrival of more Confederate troops along the heights, the Union forces withdrew to the other side of Antietam Creek (White, 1997). The single bloodiest battle of the American Civil War was over for the day.

Soils

The unconsolidated sediments overlying the rocks in the *Hagerstown Valley* include transported materials as well as materials formed in place. Transported materials comprise alluvium and terrace deposits along streams, and colluvium along the flanks of mountains east and west. The materials formed in place include weathering products and soils. Total soil thickness varies from nothing (exposed bedrock) to over 100 feet in the valley (Duigon, 2001). Depending on the parent material, soils of the *Hagerstown Valley* tend to be medium texture, well drained, and deep to shallow. Parallel linear outcrops (clints) may separate areas of deep soil (grikes). These outcrops are the edges of steeply dipping strata, and the deep soil between them has formed along the bedding planes (Duigon, 2001). The *Hagerstown Valley* contains limestone-derived soils that are highly productive for agriculture uses. Many acres of forests have been cleared in the *Great Valley* region for agriculture. The Nature Conservancy has estimated that only 1500 acres of an original 500,000 acres of limestone forest remains undisturbed in Maryland (National Park Service, 1996).

ANTI currently has the 2002 Washington County Soil Survey for the battlefield entered in the park's geographic information system (GIS). Soil resources at ANTI are to be preserved; thus, the unnatural erosion, physical removal, and contamination of soils will be prevented to the extent possible (Wenschhof, 1997). Park management is encouraged to consider crop selection, crop rotation, minimum tillage, grassed waterways, mulching, contour farming, strip farming, terracing, and the use of various soil amendments when designing a land use plan for a historic district where the interpretive theme calls for using agricultural tillage practices (National Park Service, 1991).

Hydrology

Watersheds

The battlefield is located within the 14,670-mi^2 Potomac River drainage basin, the fourth largest watershed on the East Coast (Belval and Sprague, 1999; National Park Service, 1995a). The Potomac River flows for 385 miles from the Allegheny Mountains to the Chesapeake Bay. Draining almost 15,000 square miles in four states, the Potomac is a major natural resource (National Park Service, 1995). The Potomac is one of nine river basins, and the second largest drainage that form the 64,000-mi^2 Chesapeake Bay watershed (see Figure 6). The Chesapeake Bay is the largest estuary in the United States, providing habitat for abundant and diverse wildlife populations and supporting an economy that includes fishing, shipping, and recreation. Currently, 136 million people live in the Chesapeake Bay watershed, which is challenged with unprecedented development (Burke *et al*., 1999).

Within the Potomac River drainage basin, ANTI is located within the Conococheague-Opequon watershed [USGS cataloging unit: 02070004] (Figure 7a). More specifically, the battlefield is contained within the Antietam Creek drainage of this watershed, draining 281 square miles at ANTI before emptying into the Potomac River (Figure 7b). A detailed map of the Antietam Creek drainage basin is included in a recent report (Duigon, 2001) prepared by the Maryland Geologic Survey. Sixty percent of the Antietam Creek drainage basin is within Washington County, Maryland (U.S. Army Crops of Engineers, 1972). Land use within this basin is 69 percent agriculture, 24 percent forest and 7 percent urban (U.S. Geological Survey, 1995).

Surface Water

Antietam Creek is one of the most significant natural features of ANTI, flowing approximately three miles through the southern part of the battlefield collecting water from several smaller perennial and intermittent tributaries, eventually emptying into the Potomac River, less than 2 miles from the park's southern boundary. The U.S. Geological Survey maintains a gaging station on Antietam Creek, 400 feet downstream from ANTI's historic Burnside Bridge on the east bank. Stream flow has been measured there from 1897 - 1905 and 1928 – present (Figure 8). The highest Antietam Creek discharge typically occurs during the spring months of March and April (400-550 cfs), with the

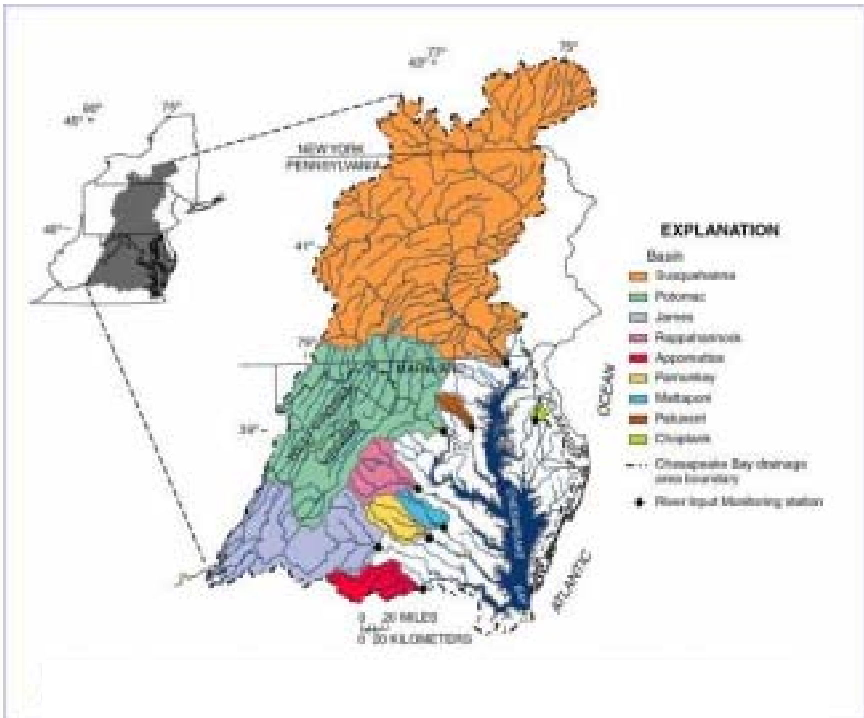


Figure 6. Location of major drainages in the Chesapeake Bay Basin (modified after Belval and Sprague, 1999)

lowest discharge occurring during the late summer months and early fall (150-250 cfs). Antietam Creek is susceptible to flooding during storm events several times a year and has a tendency to flash flood. Sediment loads can be heavy during such events (Maryland Department of Natural Resources, 1997).

Sharpsburg Creek, an Antietam Creek tributary, originates from a spring in the town of Sharpsburg. Approximately 2,800 feet of Sharpsburg Creek flows within ANTI. The creek flows adjacent to a private sheep pasture, adjacent to and through a cattle pasture on the NPS Sherrick Farm, and the remainder parallels the Burnside Bridge Road before flowing into Antietam Creek (Wenschhof, 1997).

Stormwater Management

With increased development in ANTI's watershed comes more impervious land area generating increased stream flow rates, water quality issues, higher runoff volumes, and increased flooding. In looking at the U.S. Geological Survey's historical discharge data at Antietam Creek (1929-2000), just below the Burnside Bridge, increases in flow appear to have occurred in the past 30 years. In comparing the accumulated annual mean discharge slope from 1929-1969 (slope = 0.003816) and 1970-2000 (slope = 0.003086), there has been a 19% change, suggesting increased flows due to watershed development (Figure 9a).

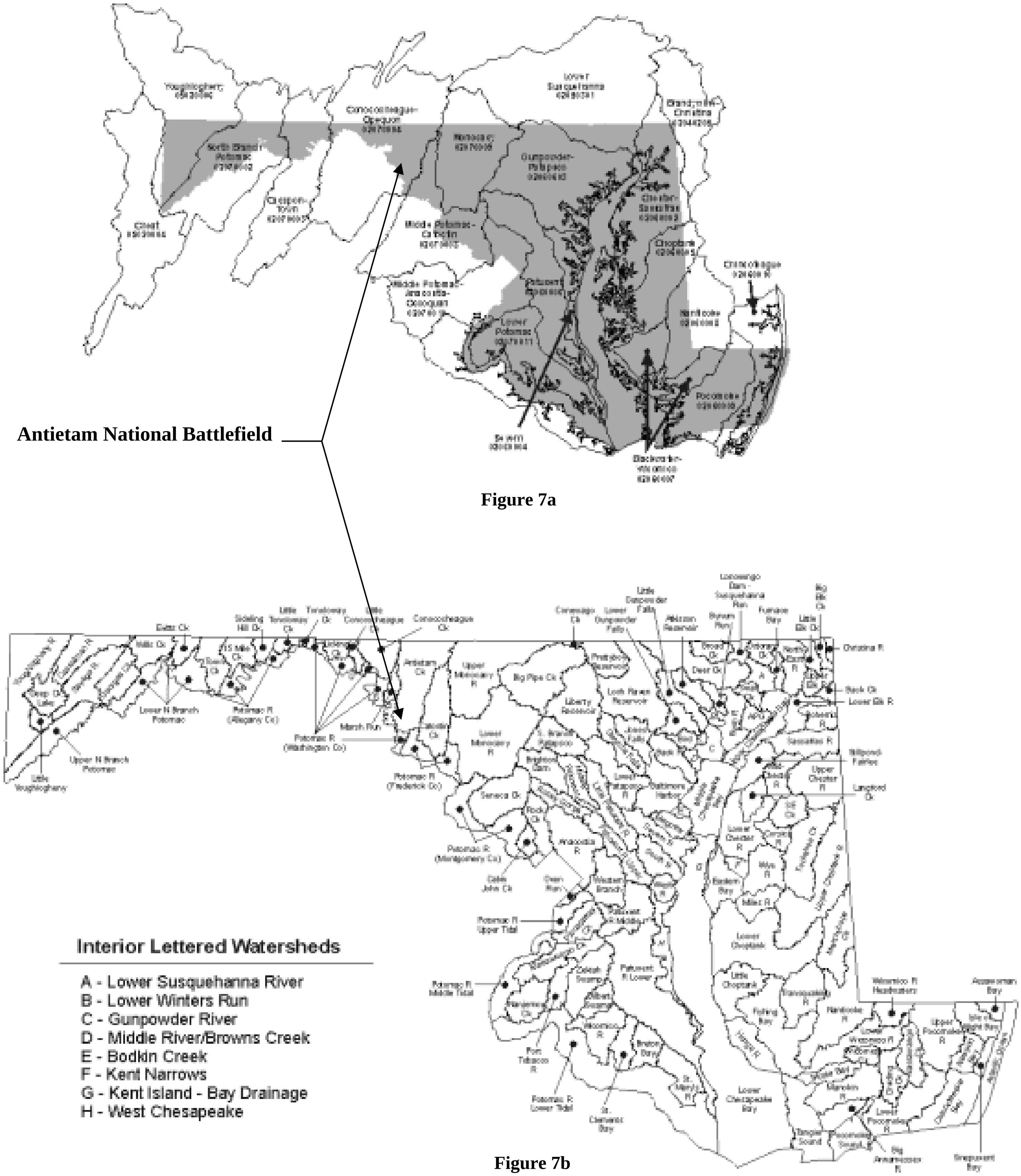


Figure 7a

Figure 7b

Figure 7. a.) Location of Conococheague-Opequon Watershed. **b.)** Maryland Drainage Basins (Maryland Department of Natural Resources, 1998).

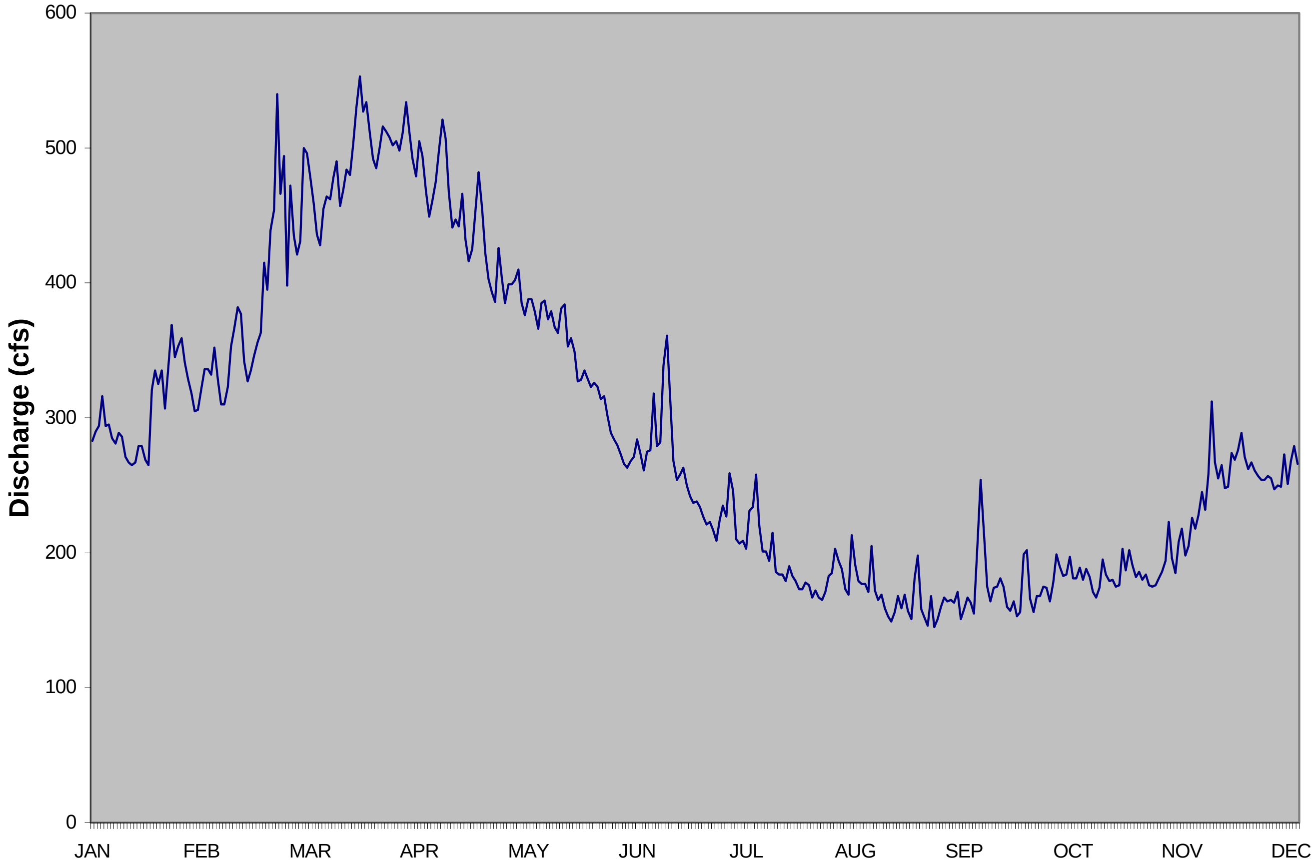


Figure 8. Antietam Creek mean daily discharge (1897-1905, 1928-2001) below Burnside Bridge (USGS Station 01619500).

Precipitation does not appear to contribute significantly to this change in discharge. As shown in Figure 9b, accumulated precipitation in the area has a slope change of only 4.7% for the same periods, up to 1994 [note: precipitation data were collected from Martinsburg, WV, approximately 13 miles from the USGS station]. Also, the highest annual mean discharges in Antietam Creek have occurred between 1970 – 2000 (Appendix A). Between 1929 and 1969 the two highest annual mean discharges occurred in 1952 (429 cfs) and 1937 (376 cfs). In contrast, the highest annual mean discharges between 1970 and 2000 occurred in 1996 (703 cfs), 1975 (563 cfs), 1972 (510 cfs), and 1998 (503 cfs). These preliminary findings warrant further evaluation of the data to determine if the difference in flows between 1929-1969 and 1970-2000 is statistically significant.

Washington County's primary approach to stormwater management has been to promote on-site absorption or quantity control through detention/retention structures. However,

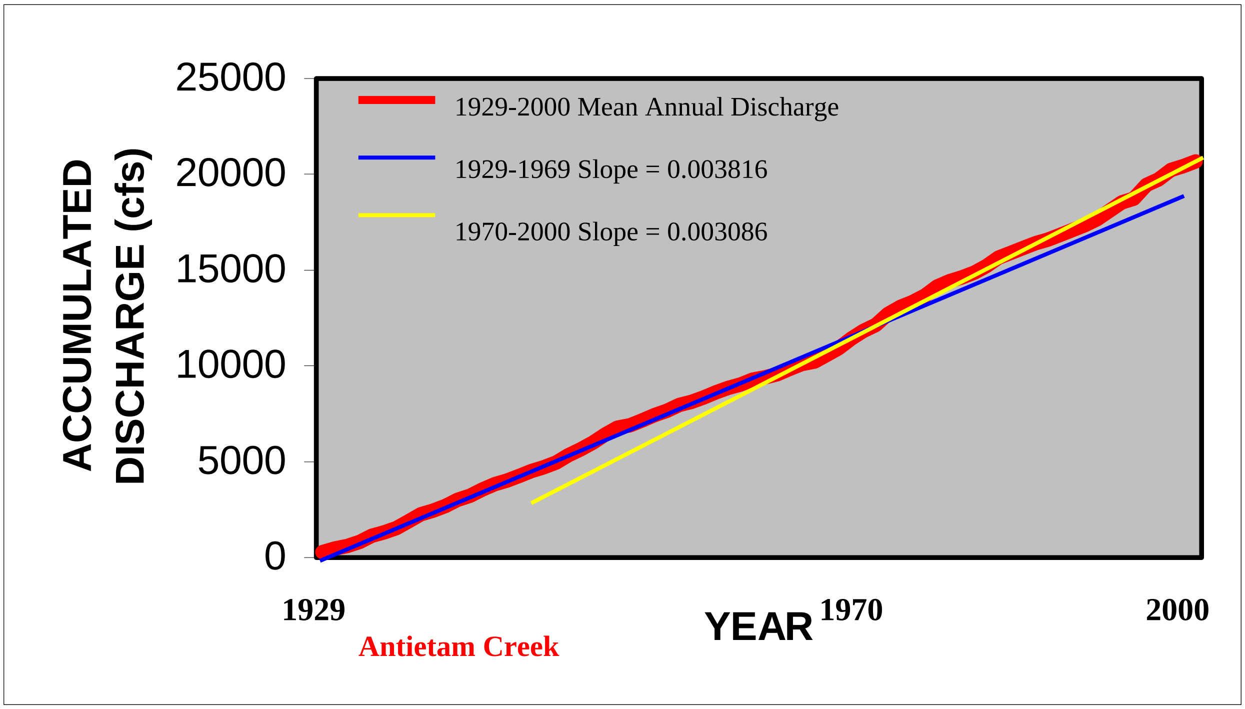


Figure 9a

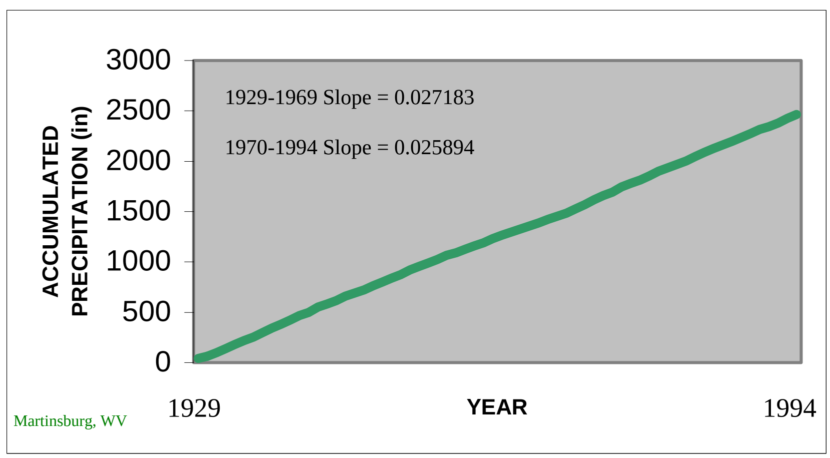


Figure 9b

Figure 9. a.) Accumulated annual mean Antietam Creek discharge (1929-2000) with calculated slopes for 1929-1969 and 1970-2000. **b.)** Accumulated Martinsburg, WV annual precipitation totals (1929-1994) with calculated slopes for 1929-1969 and 1970-1994.

new national stormwater management regulations require addressing the issue of water quality as well as quantity when designing stormwater management facilities. This has resulted in a more regional approach in locating stormwater management facilities so that they can be better monitored and maintained (Washington County-Maryland, 2001).

In 1991, the Maryland Forest Conservation Act was passed due to loss of forest cover to urbanized development. The Act requires that all of Maryland's counties with less than 200,000 acres of forest cover must adopt an ordinance to address the issue of forest conservation through identification and protection of existing forest, and establishment of new forest. In 1993, the Forest Conservation Ordinance for Washington County was adopted. Under this ordinance, land development that removes 40,000 ft^2 of forest area requires mitigation plans submitted to the Planning Commission for approval (Washington County-Maryland, 2001).

Floodplains in parks should be managed in accordance with *Executive Order 11988* (Floodplain Management) and *Special Directive 93-4: Floodplain Management Guideline*. Structures and facilities that must be located in floodplains require designs consistent with the intent of the *Standards and Criteria of the National Flood Insurance Program* (44 CFR Part 60). When conflicts between infrastructure (e.g., historic bridges) and stream processes are unavoidable, NPS management should use techniques that are visually non-obtrusive and that accommodate natural processes to the greatest extent possible. A Statement of Findings must be prepared for actions to be located in a floodplain (National Park Service, 2000).

<u>Riparian Forest</u>

The natural riparian areas along the streams in and around ANTI contain diverse, dynamic, and complex biophysical habitats. These riparian areas are known to be important in controlling the physical and chemical environment of streams and in providing detritus and woody debris for streams and near-shore areas of water bodies. According to the Maryland Department of Natural Resource (1997), the riparian habitat along Antietam Creek and its tributaries is a significant component of water quality maintenance in the watershed. For example, riparian forests of mature trees (30 – 75 years old) are known to reduce delivery of nonpoint source pollution to streams and lakes (Lowrance *et al*., 1985). Riparian vegetation has well-known beneficial effects on bank stability, biological diversity and water temperatures of streams (Karr and Schlosser, 1978). These interfaces between terrestrial and freshwater ecosystems are very sensitive to environmental change (Naiman and Décamps, 1997).

<u>Wetlands</u>

Wetlands represent transitional environments, located between uplands and deepwater areas. Flora within these wetland systems exhibit extreme spatial variability, triggered by very slight changes in elevation. Temporal variability is also great because the surface water depth is highly influenced by changes in precipitation, evaporation and/or infiltration. Cowardin *et al.* (1979) developed a wetland classification system that is now the standard in the federal government. In this system, a wetland must have one or more of the following attributes: (1) at least periodically, the land supports predominately hydrophytes; (2) the substrate is predominately undrained hydric soil; and (3) the substrate is non-soil and is saturated with water or covered by shallow water at some time during the growing season of each year. There are four federal government agencies responsible for identifying and delineating wetlands: the Army Corps of Engineers, Environmental Protection Agency, Fish and Wildlife Service, and Soil Conservation Service.

In reviewing the National Wetlands Inventory (NWI) maps prepared by the U.S. Fish and Wildlife Service, two wetland types are identified at three locations within ANTI's boundary. 1) riverine, perennial, open water, permanently flooded (R5OWH) along Antietam Creek, 2) palustrine, forested, broad-leaved deciduous, temporarily flooded (PFO1A), at the confluence of Sharpsburg Creek and Antietam Creek, and 3) PFO1A at the confluence of the drainage from the Roulette Farm and Antietam Creek (U.S. Fish and Wildlife Service, 2002).

In 1990, a wetlands survey of the federally owned lands within ANTI was completed for the 1992 General Management Plan (National Park Service, 1992). According to the survey, wetlands at the park were confined to riverine or channel-limited systems, because the overall landscape of well drained soils and underling karst geology were not conducive to wetland formation (National Park Service, 1990, 1992). From the survey, five drainages in ANTI contained wetlands, which included the wetlands identified on the NWI maps (National Park Service, 1990):

> *Drainage #1* originates from Mumma Spring. The stream channel is small and encroached by grass and weed from the adjacent fields. No obligate wetland vegetation was located. However, as a perennial stream, the drainage is classified as a riverine wetland.
>
> *Drainage #2* is comprised of a small intermittent drainage channel at the end of the driveway of the Piper Farm and a primary intermittent or dry drainage valley below Bloody Lane. The drainage channel below the driveway is designated as a riverine wetland due to periodic flow and hydric soils. No hydrophytic vegetation was present.
>
> *Drainage #3* consists of the upper perennial riverine stream emanating from Sharpsburg and flowing past the Sherrick House alongside Burnside Bridge Road before reaching Antietam Creek. This stream channel is a riverine wetland on the basis of hydrology and wetland vegetation (jewelweed and elderberry) within the stream banks.
>
> *Drainage #4* consists of Antietam Creek and its floodplain roughly from Burnside Bridge downstream to Horseshoe Bend where it leaves NPS property. This system is riverine with the floodplain being constricted and consisting of little more than stream banks. The area is classified as a wetland based on hydrology and the presence of facultative wet vegetation (blue lobelia, jewelweed, sycamore, elm, tulip poplar, and boxelder). The mottled soil at the small horseshoe bend just downstream from the USGS gaging station suggests that this small area should be considered a wetland.

Drainage #5 is adjacent to the park boundary paralleling a gravel road off the Harper's Ferry Road (Rt. 65) just south of the Branch Avenue intersection. This stream system is upper perennial riverine in character, and consists of a narrow stream channel. The stream terminates at Antietam Creek.

<u>Ground Water</u>

As stated earlier, ANTI is underlain predominately by carbonate rocks (limestone and dolomite), producing an environmentally sensitive karst terrain. In a karst landscape, much of the ground water flow takes place in pipe-like or sheet-like voids that have been created and/or enlarged by the solvent action of circulating water. Consequently, the aquifer is heterogeneous and ground water does not follow all the rules of typical ground water movement, as developed for homogeneous media (Duigon, 1997). Recharge to a karst aquifer can be diffuse, as widespread precipitation infiltrates the overlying soils and sediments. Recharge can also be concentrated, as surface runoff is directed into a sinkhole or losing stream. The development of the network of solution conduits joining recharge and discharge depends on topography, lithology, and geologic structure (Duigon, 1997). According to Duigon (2002), geologic structure is the dominant control on ground water flow of the *Hagerstown Valley*. Bedding plane separations and strike-parallel joints direct ground water, under the driving force of the hydraulic gradient, to flow parallel to the strike of bedding, which is typically toward the north-northeast or south-southwest. A ground water map for Washington County, including the battlefield, is included in a recent report (Duigon, 2001) prepared by the Maryland Geological Survey.

There are several springs located in ANTI. Along with their natural significance to the surrounding landscape and ecology of the park, many of these springs are important to the cultural context of the park. Mumma Spring, located on Mumma Farm, flows through a historic spring house via a cement trough. The U.S. Geological Survey has taken monthly discharge measurements from the spring since 1991. The extreme discharges for the period of record are 0.3 gallons per minute (gpm) [10/4/91, 11/7/91] and 95.0 gpm [5/14/98].

There are two natural springs located on the Haines Tract (Tract 01-101). One is protected by a stone spring house. A ground level concrete slab covers the spring that is about five feet below ground surface. The second spring is not protected by any structure. This spring surfaces from under a rock in an adjacent rock outcropping east of the first spring (Wenschhof, 1997).

On the Miller Farm, a small spring house protects the Miller Spring located on the east edge of Dunker Church Road. Discharge from this spring is routed by an underground pipe, under the road, to a cistern that waters livestock. Discharge from the cistern is routed to the spring's natural drainage outside of the fenced area.

There are several ground water wells located on the following units at ANTI: Lohman Tract (1), D.R. Miller (2), A. Poffenberger (1), Pry (1), Rohrbach Group Campground

(1), Roulette (1), Cunningham (3), Fulk (1), Wyand (1), Smith (1), J. Poffenberger (2), Piper (2), and the Visitor Center (1). The wells located at the Miller Farm, Piper Farm and Poffenberger Farm could be impacted by agricultural influences to the wellheads (Wenschhof, pers. comm., 2002). Several of these wells provide water for human and livestock use.

Currently, there is only one wellhead protection area designated in Washington County. It is located in the Boonsboro area where four wells are used to supply the town's water demands (Washington County-Maryland, 2001).

Water Quality

The pollution of surface waters and ground waters by both point and non-point sources can impair the natural function of aquatic and terrestrial ecosystems, and diminish the utility of ANTI waters for visitor use and enjoyment. In the Potomac River Basin, the quality of streams and ground water is affected by a variety of natural and human processes. The karst aquifers underlying the battlefield are susceptible to contamination because they are not protected by an overlying confining bed such as a thick clay. Several major types of chemicals found in water in the basin include nutrients, trace elements, pesticides, chlorinated industrial compounds and volatile organic compounds (Ator *et al*., 1998). Table 1 highlights the water quality assessment presented in a 1998 U.S. Geological Survey report. The report summarizes water quality data collected in the Potomac River Basin between 1992 and 1995, as part of the National Water-Quality Assessment (NAWQA) program for the Potomac River Basin Study Unit.

In 1995, the NPS Water Resources Division completed a comprehensive summary of existing surface-water quality data for ANTI, the *Baseline Water Quality Inventory and Analysis, Antietam National Battlefield* (National Park Service, 1995). The study area for this inventory is defined as approximately three miles upstream and one mile downstream from ANTI's boundary. The information contained in this report represents data retrievals from six EPA national databases; (1) Storage and Retrieval (STORET); (2) River Reach File (RF3); (3) Industrial Facilities Discharge (IFD); (4) Drinking Water Supplies (DRINKS); (5) Flow Gages (GAGES); and (6) Water Impoundments (DAMS). The stations yielding the longest-term records within ANTI's boundary are: (1) Antietam Cr At Gag Sta Bel Burn. Br Nr Sharp. (ANTI 0039); (2) Antietam C Nr Sharpsburg, MD (ANTI 0040); (3) At Gaging Sta. Just Below Burnside Bridge Nr. Sh (ANTI 0041); (4) Antietam Creek At Burnside Bridge (ANTI 0044); (5) Sharpsburg Creek Entering the Antietam (ANTI 0045); (6) Antietam Creek At Snavely Ford (ANTI 0046); (7) Mumma Spring Leaving Park (ANTI 0047); (8) Sharpsburg Creek Sherrick Farm (ANTI 0048); (9) Mumma Spring At Source (ANTI 0050); (10) WA Di 103 (ANTI 0051); and (11) Sharpsburg Creek Entering Park (ANTI 0055). The stations yielding longer-term records within the study area, but outside the park boundary are: (1) Antietam Creek – Pry Farm (ANTI 0036); (2) Potomac River At Gag. Sta. Be. Br. On Rt. 34 (ANTI 0060); and (3) Potomac R. At Shepherdstown, WV (ANTI 0062). It should be noted that the water quality station descriptions are verbatim from STORET.

Table 1. Water Quality Assessment of the Potomac River Basin, 1992-1995 (Altor *et al*., 1998).

Nutrient inputs to the Potomac River Basin are related to landuse. Agricultural areas receive the largest amounts of nutrients (45% nitrogen and 93% phosphorus inputs).
Elevated nitrogen concentrations in streams and ground water are common in areas of intensive row cropping and areas underlain by carbonate bedrock (i.e., limestone environments). Tributaries draining agricultural areas yield the greatest quantity of nitrogen to the Potomac River; streams draining agricultural and urban areas yield the greatest quantities of phosphorus.
In most waters of the Potomac River Basin, concentrations of nutrients do not pose a threat to human health or wildlife.
Commonly used pesticides are present in ground water in the Potomac River Basin, but typically at concentrations that are not threatening to human health. More pesticides were detected in streams than in ground water, but only rarely at concentrations threatening to aquatic life.
Pesticides are commonly detected in agricultural areas of the Potomac River Basin, particularly in areas of intense crop production (e.g., *Great Valley*). Maximum concentrations of most pesticides occur in streams during the spring and early summer months, coincident with their application to fields, although atrazine and metolachlor are present year round in streams in agricultural areas. Samples collected from forested areas rarely contained detectable pesticides.
Higher concentrations of agricultural chemicals were detected in streams located in carbonate terrain (i.e., limestone environments of the *Great Valley*).
Chlorinated organic compounds, mercury, and lead are present in streambed sediment at concentrations that have some potential to adversely affect aquatic life. Banned chemicals are still being detected in sediments (i.e., chlordane (banned in 1998), DDT (banned in 1972)).
Radon is present in ground water throughout the Potomac River Basin and is related to rock type. High levels of radon are typically associated with crystalline and siliciclastic rocks found in the eastern parts of the basin. Sixty-nine percent of ground water samples were greater than the EPA drinking-water standard (300 picocuries/liter).

Monitoring sites within the park's boundary that exceeded the screening criteria one or more times were ANTI 0042, ANTI 0046, ANTI 0045 (dissolved oxygen); ANTI 0041, ANTI 0050, ANTI 0055 (pH); ANTI 0040, ANTI 0041, ANTI 0043, ANTI 0047 (turbidity); ANTI 0039, ANTI 0041, ANTI 0042, ANTI 0043 (total coliform); ANTI0039, ANTI 0040, ANTI 0041, ANTI 0042, ANTI 0043 (fecal coliform); ANTI 0047, ANTI 0050 (nitrate (including dissolved and total as N and NO_3)); ANTI 0040 (total cyanide); ANTI 0040 (copper (including dissolved, suspended and total)); ANTI 0040 (lead (including dissolved, suspended and total)); and ANTI 0040 (zinc (including dissolved, suspended, and total)). See Appendix B for sampling locations in ANTI.

The 1995 baseline water quality report for ANTI provides specific information and selected graphical summaries on water quality data retrieved during the inventory (National Park Service, 1995). According to the report, potential anthropogenic sources of contaminants include recreational use, agriculture, residential development, and acidic atmospheric deposition.

Marsh Run, Little Antietam Creek, and Beaver Creek are all sub-watersheds of Antietam Creek and located upstream of ANTI. The Washington County Soil Conservation District has selected these three drainages in a "targeted watershed project". Marsh Run and Little Antietam Creek watersheds were targeted in 1992 because they are representative of the overall natural resources, farming operations, and water quality problems of the entire Antietam Creek Watershed. In 1996, the Beaver Creek watershed was added due to concerns about protecting special planning areas such as the Albert M. Powell Trout Hachery and Greenbriar State Park. The objectives of this project are to (Washington County Soil Conservation District, 2000):

- Increase public awareness about agricultural and urban sources of non-point source pollution and practices or actions that can be used to reduce or prevent them.
- Make significant improvements in water quality of surface and ground water resources.
- Make measurable improvements in the living resources of the surface waters and associated riparian areas.
- Use proven technology to meet the objectives, and demonstrate and evaluate innovative measures that will expand the limits of technology.

ANTI is located in the NPS National Capital Inventory and Monitoring Network, which is funded (beginning in FY01) through the Natural Resource Challenge to design and implement a network water quality monitoring program. This program is to be fully integrated with the network-based Park Vital Signs Monitoring Program. The overall objective of the water quality component of Vital Signs is to improve the quality of impaired waters and to maintain the quality of pristine waters in parks. Specifically, by 2005, 85% of the NPS units will have unimpaired water quality. To date, interviews and questionnaires have been completed for the National Capital parks and the information has been incorporated into park summaries. Information has been taken from the Maryland Biological Stream Survey (MBSS) method and fit into the recommended outline for vital signs monitoring. A reviewable draft of the park summaries, including ANTI, and the basic methods for monitoring are scheduled for July 2002 (Norris pers. comm., 2002).

Atmospheric Deposition

More than 10 years ago, the Maryland Department of Natural Resources recognized that atmospheric deposition was one of the most important environmental problems resulting from the generation of electric power (Millard *et al*., 2001). The National Atmospheric Deposition Program/National Trends Network (NADP/NTN) collects data on both pollutant deposition (in kilograms per hectare per year) and pollutant concentration (in microequivalents per liter). Deposition varies with the amount of annual on-site precipitation, and is useful because it gives an indication of the total annual pollutant loading at the site. Concentration is independent of precipitation amount; therefore, it provides a better indication of whether ambient pollutant levels are increasing or decreasing over the years. In 2000, wet deposition and concentration of sulfate, and wet deposition of nitrate were high in the northeast U.S., including Maryland, relative to the rest of the United States. Wet concentration of nitrate was also high in the northeast U.S. Wet ammonium concentration was relatively low in the northeast U.S., while wet ammonium deposition was moderate in the northeast (see U.S. wet deposition isopleth maps at http://nadp.sws.uiuc.edu).

A review of the 1995 *Baseline Water Quality Data Inventory and Analysis* report for ANTI indicated many water chemistry data have been collected in the park. Samples collected at various locations along Antietam and Sharpsburg Creeks between 1963 and 1994 had a mean pH of 7.9 and average acid neutralizing capacity (ANC) values of 90-1544 microequivalents per liter (μeq/L). Acid-sensitive surface waters typically have a pH below 6.0 and an ANC below 100 μeq/L. Therefore, these data indicate surface waters in ANTI are not sensitive to acid deposition (Maniero, pers. comm., 2002). Fortunately, the carbonate geology at the battlefield helps to neutralize acid deposition.

Biological Resources

Water resources are especially important to the success of ANTI's flora and fauna. ANTI should seek to perpetuate the native animal life and native plant life as part of the natural ecosystems and historical scene of the national battlefield. "Native" biological resources are defined as all species that as a result of natural processes have occurred, now occur, or may occur in the future on lands designated as national parks (National Park Service, 2001). Along with providing some basic background information, the purpose of this section is to begin exposing some of the biological concerns in the region that may apply to ANTI and serve as indicators to water-related issues. The Maryland Biological Stream Survey was conducted for Washington County from 1994-1997. In evaluating the data collected from this survey, the overall health of streams in Washington County can best be described as "Fair" to "Poor" (Millard *et al*., 2001).

In a 1996-97 "Natural Areas" inventory conducted at ANTI by the Maryland Department of Natural Resources, the following list of ecological assets at ANTI was produced:

- Riparian buffer along Antietam Creek
- Large block of limestone upland forest and floodplain (Snavely Ford Woods)
- Rare and threatened plants (Snavely Ford Woods)
- Rare land snails (Snavely Ford Woods)
- Rare species associated with springs

The natural habitats at ANTI were ranked [1 (highest) – 7 (lesser quality)] by the Maryland Department of Natural Resources (1997):

1. Snavely Ford woods and trail
2. Hawkins Zouaves Monument Spring
3. Mumma Farm spring
4. D.R. Miller Cave

5. Antietam Creek riparian buffer
6. Old field and fence rows near observation tower (loggerhead shrike habitat)
7. BSA/Sherrick Trail (edge habitat)

Fauna

Many species of wildlife were documented during 1987 wildlife surveys by park staff. Species reported in ANTI included woodchucks, gray squirrels, mallards, rock doves, turkey vultures, mourning doves, blue jays, white-tail deer, red fox, and raccoon (National Park Service, 1992).

Antietam Creek once supported native brook trout. Rainbow trout were stocked in the creek until 1987. ANTI decided to discontinue the state stocking of the creek because of visitor impacts associated with fishing (i.e., streambank deterioration, litter, etc.) (National Park Service, 1992). A previously undescribed species of sculpin, *Cottus*, was found to be widely distributed and abundant in Antietam Creek and its tributaries during a 1992 survey (Reasly, 1992). According to the Maryland Department of Natural Resources (1997), ongoing monitoring of the sculpin should take place and preservation/restoration of riparian habitat is crucial. In 1997, two springs (Mumma House Spring and Hawkins Zouaves Monument Spring) and a small cave (D.R. Miller Cave) at ANTI were surveyed for subterranean macroinvertebrates. The survey yielded four new occurrences of subterranean macroinvertebrates (Table 2). All subterranean planaria are exceedingly rare in Maryland and thus all should be protected (Maryland Department of Natural Resources, 1997).

Table 2. Summary of subterranean macroinvertebrate survey results from Antietam National Battlefield (Maryland Department of Natural Resources, 1997).

Site Name	Location	Subterranean Species	State Status
Hawkins Zouaves Monument Spring	0.25 km south of Hawkins Zouaves Monument	*Stygobromus gracilipes*	Endangered
Mumma House Spring	0.43 km NE of Visitors Center	*Caecidotea pricei* (confirmation required through male species)	Watch List
D.R. Miller Farmstead Cave/Spring	8 m east of Dunker Church Road	*Caecidotea pricei* (confirmation required through male species)	Watch List
D.R. Miller Farmstead Cave/Spring	0.6 km south of Mansfield Ave.	Subterranean planarian (to be identified)	Highly Rare

Several species of subterranean macroinvertebrates indicated that water quality is fairly good at ANTI, although surveys revealed no live freshwater mussels. Evidence that freshwater mussels were recently living within Antietam Creek, from recovered dead shells, suggests a single event (possibly an upstream chlorine dump a few years ago) killed mussels or their fish host (Maryland Department of Natural Resources, 1997). If so, Antietam Creek could be recovering slowly from this event since recent benthic invertebrate surveys revealed healthy populations.

There are no federally listed fauna within ANTI. Two candidate species are present in the area: the migrant loggerhead shrike (*Lanius ludovicianus migrans*) and Appalachian Bewick's wren (*Thyromanes bewickii altus*). The loggerhead shrike has been documented in the park since 1983. Although the Appalachian Bewick's wren has not been sighted in Maryland since the early 1980s, ANTI offers wren habitat along the edges of the remaining deciduous forests (National Park Service, 1992). The Maryland Department of Natural Resources feels that ANTI could also provide suitable habitat for two species of freshwater mussels, the green floater (*Lasmigonal subviridus*) and brook floater (*Alasmidonta varicosa*) (Wenschhof, 1997).

<u>Flora</u>

At one time, most of Washington County was covered with hardwood forests. The limestone bedrock areas of the *Hagerstown Valley* had significant forests that included oak, hickory, beech, ash and basswood (Washington County-Maryland, 2001). The vegetation now at ANTI reflects a long history of anthropogenic disturbance and manipulation. Over time, clear-cutting for farming took place as the area was settled. Approximately 40 acres within ANTI's boundary are currently old-growth forest. Snavely Ford is the largest natural area in the battlefield and supports one of the best developed native oak/hickory forests on limestone remaining in Washington County, Maryland (Maryland Department of Natural Resources, 1997). In addition to maintaining the traditional agricultural use of the landscape, the NPS has also established a goal to reforest approximately 345 acres of woodland that was present in 1862 (National Park Service, 1992).

Along with clearing land, residents introduced many species of exotic plants. A vegetation inventory (1983-1985) revealed that most of the species in ANTI were exotic. Invasive non-native plants such as Japanese honeysuckle (*Lonicera japonica*) and garlic mustard (*Alliaria officianlis*) are aggressively competing with native species. It is not known whether any of these species existed at the time of the battle (National Park Service, 1992).

There are no federally listed plant species in ANTI. The Maryland State Natural Heritage Program lists one species, the white trout-lily (*Erythronium albidane*), that is proposed for addition to the Maryland Endangered and Threatened Species List. The trout lily has suitable floodplain habitat in ANTI between Snavely Ford and Burnside Bridge. The Maryland Department of Natural Resources has identified a population of the lily growing just outside the park's boundary (National Park Service, 1992). In a 1997 vegetation survey at ANTI, the rare and threatened plants listed in Table 3 were identified (Maryland Department of Natural Resources, 1997).

Table 3. Summary of Rare and Threatened Plants at Antietam National Battlefield (Maryland Department of Natural Resources, 1997).

Common Name	**Scientific Name**	**Status**	**Habitat Management Needs**
Goldenseal	*Hydrastis canadensis*	State Threatened (listed 1991)	Need to protect from collection. Research long-term viability of small population.
Butternut	*Juglans cinera*	State Watchlist	Single individual seen.
Dwarf Larkspur	*Delphinium tricorne*	State Watchlist	Monitor
Showy Orchis	*Galearis spectabilis*	State Watchlist	Need to protect from collection
Golden Alexanders	*Zizia aurea*	State Watchlist	Monitor
Wild Chervil	*Chaerophyllum procumbens*	State Watchlist	Monitor
Cow Parsnip	*Heracleeum lanatum*	State Watchlist	Monitor

WATER RESOURCE ISSUES

The park's water-related issues presented in this section were identified during a two-day information-gathering effort in ANTI by the author. Along with a technical literature review, information sources included interviews with NPS staff and other federal and state agencies.

Baseline Inventory and Monitoring

To effectively manage natural resources, inventory and monitoring activities should integrate into the overall natural resources planning and management process. Information obtained from these activities better assists the NPS toward understanding how the various environments in a park unit function naturally, and helps isolate anthropogenic changes. According to the NPS, *Natural Resources Inventory and Monitoring Guideline* (NPS-75), NPS units have the primary responsibility for implementing inventory and monitoring programs. A major issue for the natural resource management program at ANTI is the lack of direction due to gaps in natural resource baseline data. As a result, the present status of the park's natural resources, including water resources, is difficult to assess due to limited baseline information. ANTI should define, assemble, and synthesize baseline inventory data describing the park's water resources under its stewardship and should monitor key aspects of these resources, including interrelationships with visitor carrying capacities at regular intervals to detect changes that may require intervention, and to provide reference points for comparison with other environments and time frames. The collection of adequate information and data to support planning and the analysis of impact of environmental resources, including cultural resources, will precede any final decisions about the preservation or treatment of natural resources (National Park Service, 2000).

The drainage basin for Antietam Creek is primarily agricultural but also includes industrial sections such as Hagerstown. Antietam Creek is ranked near the top of Maryland's "Nutrient Control Priority Watershed List" and ranks 8th in Maryland for nutrient loading to the Chesapeake Bay (Washington County Soil Conservation District, 2000). Pollutants associated with industry and agriculture can quickly degrade stream habitat. Impacts to Antietam Creek are being documented in the freshwater mussel community. Mussels are extremely sensitive to change in stream water quality due to siltation, heavy metals, sewage effluent, and pesticides. Recent surveys indicate that freshwater mussels are currently in decline in Antietam Creek (Maryland Department of Natural Resources, 1997). These surveys should continue as best management practices (BMPs) are employed, to evaluate effectiveness of management actions and document species recovery at ANTI.

All ground waters sampled in a 1997 survey at ANTI were ecologically impacted to some degree, primarily from agricultural practices. These waters showed excessive siltation and algae growth, indicative of elevated erosion rates and nutrient levels (Maryland Department of Natural Resources, 1997). The following steps have been recommended by the Maryland Department of Natural Resources (1997) to ensure the continued survival of ground water limited faunas within ANTI:

1. Obtain baseline water quality data.
2. Delineate the catchment basin.
3. Minimize, and if possible, eliminate herbicide and pesticide use within the catchment basin.
4. Minimize, and if possible, eliminate excessive nutrient input to the catchment basin.
5. Restore natural flow regime, nutrient input, and erosion rates in the catchment basin.
6. Monitor water quality.

Recommendation #5 could conflict with ANTI's enabling legislation. For example, in order to restore the natural flow regimes and erosion rates, reforestation of agricultural fields would be a solution. Reforestation would disrupt the cultural landscape at ANTI. So the various management approaches require careful consideration in the battlefield.

Antietam Creek is a 303(d)-listed impaired waterbody (ID: MD-02140502-R-11-1998). The parameters of concern for Antietam Creek are nutrients, dissolved oxygen, and suspended sediment (U.S. Environmental Protection Agency, 2002). Contamination of water resources by pesticides is another concern in the Antietam Creek drainage basin. Major agricultural herbicides used in the area include atrazine and cyanazine for corn, simazine for corn and alfalfa, and alachlor and metolachlor for soybeans and corn. Simazine is also used in apple orchards, which are common in the *Hagerstown Valley*. Prometon is an important herbicide used in industrial areas for total vegetation control. In 1994, the U.S. Geological Survey evaluated the occurrence of herbicides in surface water in the Potomac River Basin, including Antietam Creek. Antietam Creek had detectable concentrations of atrazine (0.300 μg/L), simazine (0.083 μg/L), metolachlor (0.088 μg/L), and prometon (0.063 μg/L). Additional study is needed to verify apparent relations between cropland and orchards and herbicide concentrations in streams (U.S. Geological Survey, 1995).

Mumma Spring (ID: WA Di 103) at the battlefield has been sampled by the Maryland Department of Natural Resources since 1990. The spring is part of a statewide network of wells and springs that are sampled every few years to document ground water quality in Maryland's shallow aquifers. Water samples have been collected twice in 1990 and 1991, and once in 1992, 1993, 1994, 1995, and 2000 (Bolton, 2001). The Maryland Department of Natural Resources also samples a site south of the Burnside Bridge on Antietam Creek, measuring several biological and chemical parameters monthly (Kemble and Wenschhof, 1995).

An ANTI Surface Water Quality Monitoring Plan (Stahlnecker, 1987) was implemented at the battlefield in 1985, continuing until 1988. The monitoring design included sampling Antietam Creek at three locations (Pry Farm, Burnside Bridge, and Snavely Ford), three locations at Sharpsburg Creek (entering ANTI, Sherrick Farm, confluence with Antietam

Creek), and two locations at Mumma Spring (springhouse and leaving ANTI). The following parameters were monitored on a monthly basis; flow, pH, water temperature, conductivity, turbidity, alkalinity, dissolved oxygen, nitrogen, chloride, phosphorus. Fecal coliform was measured once every two weeks on a seasonal basis.

ANTI has grown since the 1980s, acquiring many neighboring parcels of land, and implemented several best management practices (BMPs) as part of the Chesapeake Bay Program (i.e., nutrient and soil management for farmers, riparian buffers, etc.). This warranted the need for a revised water quality monitoring plan. In response, a second water quality monitoring plan was implemented by ANTI in 1999. The design and implementation of this monitoring plan serves to accomplish the following objectives: 1) to establish baseline water quality information and detect long-term changes or patterns in ANTI's ground water and surface water, 2) to monitor the effects of land management practices on water resources within the park's boundaries and to identify other internal and external pollution agents, and 3) to evaluate ANTI's ability to meet and exceed local, state, and federal standards for all water resources within ANTI's boundary (Antietam National Battlefield, 1999). The six sampling sites include: Mumma Spring (2 sites), Miller Spring (1 site), Haines Spring (1 site), Roulette (1 site), and Newcomer (1 site). Water quality parameters selected for these sites include water temperature, pH, dissolved oxygen, nitrate-nitrogen, and orthophosphate.

Annual water resources reports are needed at ANTI to provide a timely understanding of the battlefield's water resource condition. This is important for park management and regional water and land managers (i.e., Maryland Department of Natural Resources, U.S. Geological Survey, Chesapeake Bay Watershed Program, etc.). These reports should capture the water quality and flow data collected within the battlefield's boundary by ANTI, the Maryland Department of Natural Resources, and the U.S. Geological Survey, including climate data (i.e., precipitation). It should be noted that Martinsburg, WV and Hagerstown, MD are the closest meteorological monitoring stations to the battlefield, thus a weather station at ANTI is warranted to correlate local weather influences on water chemistry and flow dynamics. Historical water quality data presented in the *Baseline Water Quality Inventory and Analysis, Antietam National Battlefield* (National Park Service, 1995) could serve as the foundation for this effort. In order to produce an annual summary report that is most useful to management and provides adequate monitoring of potential anomalies and long-term trends, a standardized format should be used to record, list, and display all data. All data should be graphically plotted on a yearly basis, showing extreme values (maximum & minimum), median values, 25th and 75th percentiles, via box and whiskers graphics. The following graphs should be considered for the standardized format:

- Yearly trends (one box & whiskers graph representing one years data) for each site.
- Yearly tends for each parameter for all monitoring stations combined.
- A yearly comparison of differences between sites (one box & whiskers graph representing one site).

- A yearly comparison of each month's data for each parameter (one box & whiskers graph representing one months data).

ANTI has a well-maintained GIS database, with a very qualified operations person, Debbie Cohen. The current GIS data themes include; soils, roads, surface hydrology, topography, hedgerows and field borders, legislative park boundary, scenic easements, and private land tracts. The park's GIS program is working to incorporate additional GIS data layers, along with new park-specific themes (i.e., wetlands, floodplains, riparian buffer restoration) to help fuel some of the park's management needs for natural resources. ANTI should inventory what GIS data sources exist externally before working to generate new park-specific data themes. For example, Duigon (2001) contains some excellent hydrogeology, hydrology, and karst inventory maps (e.g., drainage basins, potentiometric surface, spring inventory, ground water well inventory, karst features, etc.) of Washington County, including the battlefield, that could be digitized into ANTI's GIS database.

Riparian Restoration

As previously discussed, Antietam Creek historically supported native brook trout. Studies conducted by the Maryland Department of Natural Resources to determine if the creek could again support a brook trout population indicated that water temperature of the creek was too warm. Effluent discharged into the creek outside of ANTI from sewage treatment plants is believed to contribute to the warmer waters (National Park Service, 1992). Reduction in riparian vegetation can also contribute to increased water temperature, along with reduced aquatic habitat such as reduction in litterfall and siltation from erosion of unstable stream banks. It has been suggested that siltation may contribute to the absence of freshwater mussels in ANTI, among other aquatic impacts (Maryland Department of Natural Resources, 1997).

At several locations along Antietam Creek and its tributaries, stream banks are unnaturally undercut and eroding. These locations are typically void of native woody vegetation due to visitor impacts in high-use areas. During the summer, recreationalists canoe, fish and tube float down Antietam Creek. These activities are on the increase and advertised in tourist brochures. ANTI's best known landmark, Burnside Bridge, is a popular access point for floaters. Commercial guides drop floaters off at this location (as many as 50 people have been observed by ANTI staff) and retrieve them at a point downstream. The steep slopes to the creek are used to access the creek, trampling vegetation and disturbing the creek substrate. If this is an appropriate recreational activity in ANTI, controlled access points should be developed.

Impacted riparian areas should be mitigated, without sacrificing important cultural landscape features, to restore stream temperatures, reduce siltation, and improve aquatic habitats. Several natural resource issues need to be addressed at the Burnside Bridge location. A concrete and rock drainage parallels a walkway on the west side of the creek, before discharging runoff onto a steep slope several hundred feet down to Antietam Creek. This concentrated discharge has resulted in excessive erosion of the slope and produced a debris fan of sediments and rock in Antietam Creek below. Small dams and velocity/energy dissipaters have been recommended for construction along the path of concentrated flow. This particular reach of the creek has little to no riparian vegetation due to an interpretive trail, Snavely Ford Trail, located on the stream bank and, as previously described, heavy visitor use. It has been speculated that the lack of riparian vegetation at this location and increased stream discharge associated with upstream development outside ANTI contributes to the bank instability and excessive erosion. Along with establishing controlled visitor access points, the Maryland Department of Natural Resources (1997) recommends that streamside trails at the battlefield allow at least 15 meters of riparian buffer, where possible.

Other recommendations presented by the Maryland Department of Natural Resources (1997) includes: 1) working with neighbors and farm leases to maintain buffer along wetlands and streams, including gullies and swales; 2) avoid mowing stream side vegetation; and 3) increase riparian buffer anywhere it does not conflict with historic interpretation.

Implementation of Riparian Forest Buffer Systems (RFBS) within the Chesapeake Bay watershed as Best Management Practices (BMPs) has been encouraged for agricultural and urban areas (Lowrance *et al*., 1995). The NPS is one of 15 federal agencies participating in this regional effort to protect the Chesapeake Bay watershed. The NPS challenge with the parks in this watershed, including ANTI, is to assure, to the extent feasible, that a forested or other riparian buffer protects all streams and shorelines. Like all other participating agencies, the NPS will have until 2010 to identify and implement riparian forest buffer restoration projects (National Park Service, 1998). ANTI has been one of the NPS leaders in this effort with 4,455 feet of new riparian buffer established within the battlefield's boundary (Cohen, pers. comm., 2002). Specific projects include the D.R. Miller Farm where fences have been installed to restrict cattle access from surface water discharge of Miller Spring, providing a 25-foot buffer. An underground pipe was installed to route the spring water to a cistern inside the fenced area to meet the cattle's water needs. Excess spring water is piped underground from the cistern back to the natural surface drainage outside the fenced area. At the Mumma Farmhouse property, the same management approach was employed. Fences were used to restrict cattle access to the Mumma Spring discharge, with underground piping used to water a cistern inside the fenced cattle area. At the Newcomer Farm, fencing was installed along Antietam Creek providing a 50-foot riparian buffer along the Newcomer Farm property. The Cunningham Farm also has some protected riparian buffer.

Agricultural Management

Agriculture is the primary means of managing about 1,241 acres of the 1,747 acres owned in fee by the U.S. Government at ANTI and is one of the management options used to achieve the mandated scene restoration. The park is broken down into farm management units in essentially the same pattern as the historic farmsteads or as purchased/donated to the NPS. There are twelve management units within the federally-owned portion of ANTI at this time (see Figure 10). Approximately 862 acres of land are cropland, and 378 acres are pastureland (Wenschhof, pers. comm., 2002).

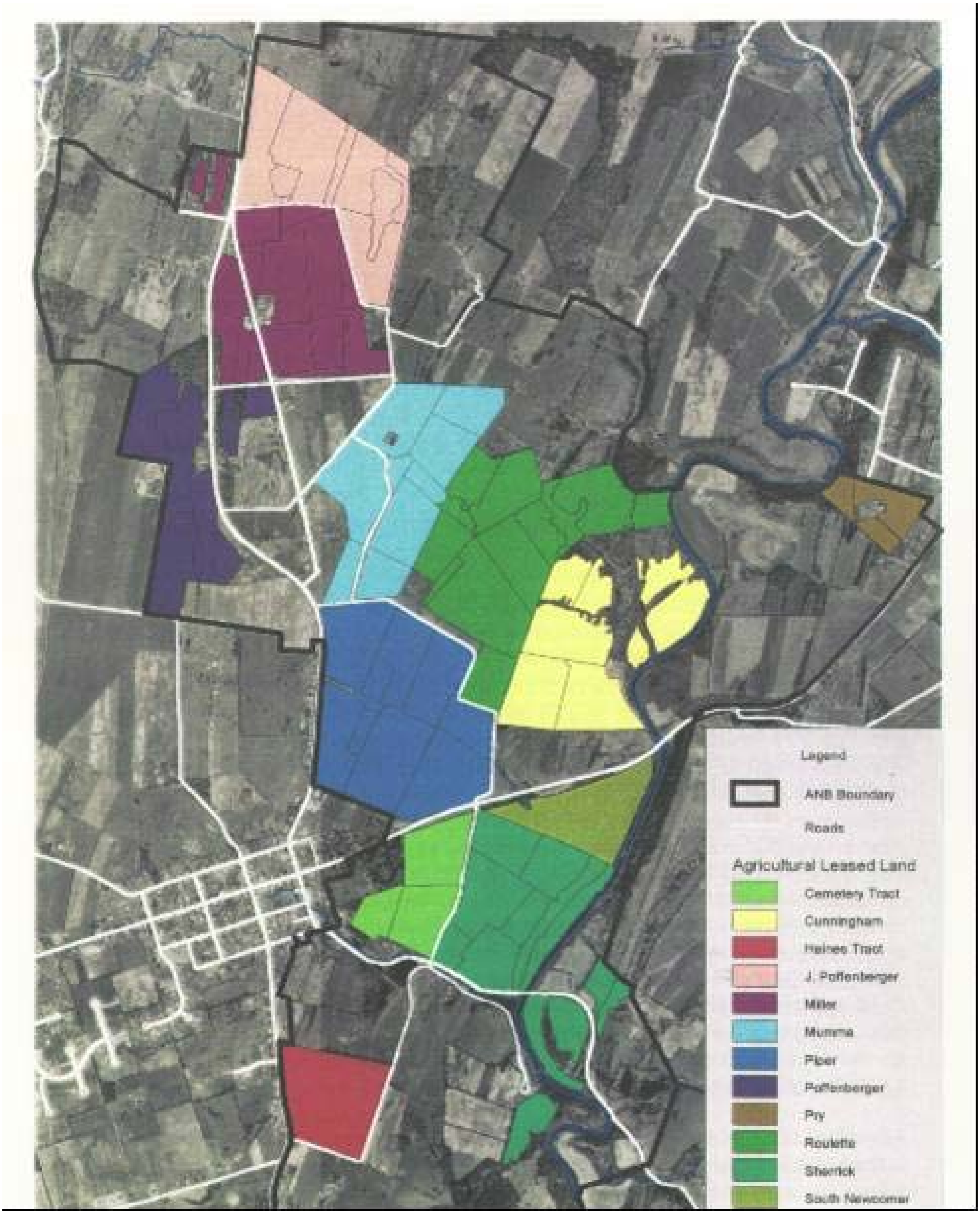


Figure 10. Antietam National Battlefield: Farms in agricultural leases.

Wenschhof (1997) evaluated the agricultural practices at ANTI. The following summarizes recommendations presented in this thesis, which serves as a management plan for ANTI:

- Agricultural crops at ANTI should consist of historically grown crops including corn, sorghum, legume hay, grass hay, and small grains (barley, oats, rye, wheat) and soybeans and alfalfa, which are important in modern rotations.

- Crop rotation is a recommended best management practice, which reduces soil erosion, runoff, improves soil fertility, and disrupts the life cycles of certain weeds, insects, and diseases.

- In crop areas, a 25-30 foot buffer zone of native grasses, shrubs, and trees should be established between cropfields and streams, or as historic scene restoration requires.

- Conservation tillage or no tillage are recommended to protect highly erodible soils. Conservation tillage systems should leave a 30 percent residue coverage, or a cover crop should be planted. Grassed waterways are recommended in fields with highly erodible soils to protect natural drainage zones. Contour tillage and strip cropping are also recommended.

- Grazing management should include restrictions on stocking rates for animals, eliminating direct livestock access to streams (25-30 foot buffer) and providing an alternative water source.

Pesticide use and selection should be based on cooperation with the NPS, Integrated Pest Management (IPM) professional, and publications. Soil active pesticides and restricted use pesticides are discouraged. Accurate record keeping and post-spray monitoring must be a part of the program.

Wastewater Treatment

High levels of bacteria have been found in springs throughout the battlefield (Antietam National Battlefield, 1999). The elevated bacteria concentrations may be related to pre-1988 conditions or from individual septic systems at homes surrounding the battlefield. Central sewage treatment for Sharpsburg was not completed until 1988.

About 40% of Washington County's population use some sort of private sewage system. The most widely used system is the conventional septic system with the cement or fiberglass holding tank and a drainage field (Washington County-Maryland, 2001). In areas like ANTI where the bedrock is shallow or water tables are high, other types of systems such as a mound and sand filter systems may be more appropriate. One of the newest varieties of septic system is the denitrification system. Though not currently being extensively used in the area, environmental concerns over the high levels of nitrogen in local waters leading to the Chesapeake Bay have created a need to look at alternative methods of sewage disposal that address the nitrogen issue.

A sewage treatment plant for the city of Hagerstown, MD is situated on the banks of Antietam Creek approximately 10 miles upstream from the northern battlefield boundary. Excessive nutrient levels have been generated in the past by this plant. Fortunately, more strict regulations limit the levels of nutrients allowed by law (Antietam National Battlefield, 1999).

Ground Water Wells and Springs

There are a number of ground water wells and springs at the battlefield. Wells that are no longer in use should be considered for plugging and abandonment since they provide a pathway for contaminants to enter the shallow karst aquifers at ANTI. Some of these inactive wells may have value for future ground water monitoring or research projects, if so, they should be properly protected from surface influences. Chemical applications to crops and animal wastes from grazing livestock (cattle) at the battlefield are concerns for both wells and springs. To protect wells and springs, the park should delineate ground water flow regimes and sensitive recharge areas (e.g., exposed limestone, sinkholes, etc.) at ANTI, and work to eliminate the application of chemicals and direct livestock access to these locations.

A field survey identified two possible sinkholes on the Poffenberger Farm, located at the West Woods reforestation area north of Confederate Avenue. Both areas were observed to be full of trash, suggesting these areas being used as dumps by local landowners (Wenschhof, 1997). Unfortunately, this practice is common in karst landscapes, where sinkholes appear to be an appropriate place to dispose of trash. Nothing could be further from the truth, since these areas represent important recharge locations for ANTI's aquifers.

Delineation of the recharge areas and ground water flows for karst aquifers underlying the battlefield is very important. In some cases, the ground water flow system boundaries may coincide with surface drainage basin boundaries, but in karst terrain, they commonly do not (Duigon, 2001). It has been suggested by the Maryland Department of Natural Resources (1997) that true watershed delineation by dye tracing methods is not practical at ANTI due to the small size of aquifers and high associated costs. The author disagrees with this conclusion. Delineation of a catchment basin in karst geology is typically approached through dye tracing techniques due to the unpredictable nature of carbonate hydrogeology. If there are several small aquifers in the area, this increases the complexity of ground water flow, and validates the need for dye tracing, in concert with other tools (e.g., potentiometric surface maps, ground water chemistry, etc), to confirm flow paths.

Failure to understand ground water flows at ANTI can be costly, not only from a natural resources perspective, but also from a cultural resources perspective. For example, the NPS drilled a geothermal well, adjacent to the Mumma springhouse, as part of the climate control system for the newly restored Mumma Farmhouse. Drilling this well altered the Mumma Spring flow, resulting in a new flow path. Now, ground water enters the historic springhouse at a reduced flow rate. The primary flow path appears to travel beneath the foundation of the springhouse before entering back into the historic surface drainage. Significant undercutting was observed around the springhouse foundation as a result of this new subsurface flow. After realizing the drilling impacts to the spring, the geothermal well was closed. Geothermal wells were then installed several hundred feet away from the spring to meet the needs of the climate control system.

Hazardous Waste Management and Spill Contingency Planning

For most NPS units like ANTI, internal NPS operations require that hazardous substances, such as petroleum products used by maintenance operations, be stored and handled on a routine basis. Although it is the goal of the NPS to minimize releases of these substances into the environment, accidental releases still occur. The action of those employees who first encounter contamination in the park could well determine the severity of the impact(s) on human health and the environment. Therefore it is important for NPS staff to understand the basic requirements for response to hazardous substance spills.

An even greater concern for hazardous spills in the park exists from external operations. A number of transportation corridors such as state and county highways can be found within or adjacent to the park. Trucks carry fuel oil, diesel fuel, gasoline, and a variety of agricultural and industrial chemicals along these corridors.

There is currently one superfund site located in Hagerstown, just upstream from ANTI. The 19-acre site owned by the Central Chemical Corporation was added to the National Priority List of Superfund sites in 1996 (Washington County-Maryland, 2001). From the 1930's until the mid-1980's, the chemical plant at the site functioned as a blender of agricultural pesticides and fertilizers. Contaminants found in soils, ground water, surface water, and sediment at the site, as well as fish tissue downstream of the site, include arsenic, lead, benzene, aldrin, chlordane, DDD, DDE, DDT, dieldrin, and methoxychlor. In 1997, EPA discovered that the site contaminants extended beyond the existing site fence line and onto property currently under development for residential use. In 2001, EPA awarded a $100,000 grant to Hagerstown under EPA's Superfund Redevelopment Initiative (SRI) Pilot Program. The city will be soliciting participation from the community to plan the reuse of the site (U.S. Environmental Protection Agency, 2002).

Stormwater from Sharpsburg drains directly into Sharpsburg Creek, which crosses ANTI property before emptying into Antietam Creek. Accidental spills in Sharpsburg would likely flow into the Sharpsburg Creek untreated, resulting in a serious threat to the health of Sharpsburg and Antietam creeks (Antietam National Battlefield, 1999).

Given these potential pollution pathways, an accidental release of hazardous materials is a continuous threat to ANTI's natural resources. The NPS is severely limited in qualified personnel, spill response equipment, and baseline natural resource information to effectively respond to and evaluate impacts from hazardous spills in ANTI. Emergency response to a major spill requires expertise and field equipment that extends beyond the capabilities of the NPS. In accordance with the National Contingency Plan established under the Clean Water Act, federal agencies are required to have a Spill Contingency

Plan (SCP) for emergency response to any spill of oil or hazardous substances for which they are responsible. Furthermore, a Spill Prevention Control and Countermeasure Plan (SPCCP) is required for the NPS to maintain compliance with 40 CFR 112 (EPA Regulations on Oil Pollution Prevention).

At ANTI, petroleum product use is focused around the maintenance yard, cemetery, visitor center, and the Roulette Farm. Petroleum storage tanks in service at the battlefield are identified in Table 4. The maintenance facility also stores numerous small containers of paints, hydraulic fluids, motor oil, and gasoline. An Oil Spill Prevention and Response Plan was completed for ANTI in 2001 (Ecology and Environment Inc., 2001). The Plan presents site-specific information on those locations at ANTI that have the potential to experience such environmental damage. In addition, general structural and operational recommendations are outlined to prevent spills associated with all on-site activities involving the storage and/or use of petroleum products or other hazardous materials. A notification sequence, including emergency contacts, is also provided if a spill occurs. The Plan is intended for use by all personnel responsible for storage, handling, and removal of hazardous substances at ANTI.

Table 4. Petroleum Storage Tank Description at Antietam National Battlefield (Ecology and Environment Inc., 2001 and Wenschhof, pers. comm., 2002).

Tank ID	Size and Type	Location	Construction	Alarmed
M1	610-gallon heating oil UST	Maintenance Shop	Protected, double walled fiberglass	Yes
M2	610-gallon gasoline UST	Maintenance Shop	Protected, double walled fiberglass	Yes
M3	610-gallon diesel UST	Maintenance Shop	Protected, double walled fiberglass	Yes
V1	2000-gallon heating oil AST	Visitors Center	Protected, double walled fiberglass	Yes
H1	275-gallon heating oil AST (2 tanks)	Park Headquarters	Protected, cement basement floor with drain	No
C1	275-gallon heating oil AST (2 tanks)	National Cemetery Lodge	Protected, cement basement floor , no drains	No
DRM-1	275-gallon heating oil AST	D.R. Miller Farm	Basement floor (protection unknown)	No
R1	275-gallon kerosene AST (2 tanks)	Roulette Farm	Not protected	No

Note: UST = underground storage tank; AST = aboveground storage tank

An environmental compliance audit was completed at ANTI in 2002 as part of a Service-wide program that requires all NPS facilities to receive an environmental audit by 2002. According to ANTI’s compliance audit report (Prizim Inc., 2002), park personnel demonstrated a good understanding of environmental regulatory knowledge and showed initiative in protecting the environment. The following recommendation summary was developed from compliance deficiencies cited during the audit site-visit:

- Formalize a document control system for environmental and health system management;
- Formalize environmental health and safety programs;
- Improve housekeeping, related to hazardous material storage and waste management; and
- Improve working conditions to reduce common hazards, including proper guards, improve working walking surfaces, and ensure exits are properly marked.

Some NPS units have introduced products and techniques that improve the quality of spill response. For example, Mammoth Cave National Park developed a hazardous spill map book (Hazmap) of each of the three transportation corridors that traverse the park's sensitive karst watershed (Fry and Meiman, 1994). These maps identify flow paths for existing drainage structures and hydrologic features with identifying landmarks along the two highways and one railway. Now when a toxic spill occurs, emergency responders use the "Hazmap" for developing quick and prudent decisions, which may avert a catastrophe within the cave system. This would be an appropriate management tool for ANTI.

In February 2002, the Hagerstown, Maryland wastewater treatment plant was shut down after bacteria used in the treatment process had been killed by a mixture of several common industrial solvents. This resulted in the plant discharging 5.7 million gallons per day of partially treated sewage into Antietam Creek. A chlorine-based system was put into place after a few days. The Maryland Department of the Environment contacted the Interstate Commission on the Potomac River Basin (ICPRB). The ICPRB was able to provide immediate fate and transport information on the spill. This information was obtained by running the ICPRB's Toxic Spill Model© (Interstate Commission on the Potomac River Basin, 2002). The information was quickly provided to each water withdrawer downstream of the stricken plant. Fortunately, the chemicals that damaged the sewage plant were not detected downstream, and probably evaporated quickly. According to ICPRB staff, the spill model is an important tool in minimizing the impact of spills in Antietam Creek and for providing safe drinking water from the Potomac River (Interstate Commission on the Potomac River Basin, 2002).

The Resource Conservation and Recovery Act (RCRA), as amended by the Hazardous and Solid Waste Act Amendments of 1984 and Title III of the Superfund Amendment Reauthorization Act (SARA Title III) require hazardous waste reduction programs. Executive Order 12873 establishes the goal for federal agencies to reduce their input into the waste stream by 40%. ANTI should implement or improve waste reduction programs through recycling efforts that are applicable to both park staff and visitors.

Wetlands Management

NPS units are required to preserve natural wetland characteristics and functions, minimizing wetland degradation and loss, and avoiding new construction in wetlands.

The NPS implements a "no net loss of wetlands" policy. *Executive Order 11990* directs the NPS: 1) to provide leadership and to take action to minimize the destruction, loss, or degradation of wetlands; 2) to preserve and enhance the natural and beneficial values of wetlands; and 3) to avoid direct or indirect support of new construction in wetlands unless there are no practicable alternatives to such construction and the proposed action includes all practicable measures to minimize harm to wetlands (National Park Service, 1998a).

As stated earlier in the report, wetlands were first identified in ANTI based on the current National Wetland Inventory (NWI) maps (1:24,000). Since smaller wetlands (<0.5 acres) are typically not captured on the NWI maps, a 1990 wetlands survey was completed for the General Management Plan, with the results presented earlier in this report (National Park Service, 1990). According to Wenschhof (1997), an intermittent drainage on the Poffenberger Farm has similar characteristics to the wetlands surveyed in 1990 at the Piper Farm. Also, stream flow from the Miller Farm spring has very similar characteristics to the Mumma Farm riverine wetland. Based on this, ANTI should formally survey these, and possibly other areas at the battlefield, to determine if additional wetland areas exist as defined by the Cowardin classification system (Cowardin *et al*., 1979).

Coordination

A park the size of ANTI with a potentially flat annual budget of $2.2 million and 38 FTEs cannot satisfy its legislative mandate without using a combination of strategies. The purchase of scenic easements, the use of volunteers for restoration projects, and cooperative agreements with local farmers to manage the park's farmland are just a few of the mechanisms the NPS uses to satisfy ANTI's legislative mandate.

The opportunity to obtain equipment and manage large field agricultural areas is not practical or affordable for ANTI. Therefore, agricultural lands are rented to local farmers, with rent returned to the park for landscape restoration and management programs. Farm cooperators are directly involved in managing and manipulating a substantial amount of park acreage. When farmland becomes available, ANTI advertises to interested parties. When an applicant is selected, a five-year agreement is prepared between the selected farmer and the NPS. The agreement contains many conditions to protect the cultural and natural resources. For example, farmers are required to possess a private applicator's license for pesticides and they must provide an accurate log of pesticide use on park lands at the end of each calendar year. Annual meetings are held each winter with the farm cooperators, county extension and conservation representatives and park staff to share information, discuss regulations, and to summarize operation requirements (Wenschhof, 1997). Nutrient management plans are now required by Maryland law (Wenschhof, pers. comm., 2002).

Activities that take place outside park boundaries and not under NPS control sometimes have a profound effect on the ability to protect park water resources and values. In recognition, the NPS is committed to working cooperatively in the management of natural resources with federal, state, and local agencies; user groups; adjacent landowners; and others. The NPS will seek to establish communication and consultation to better achieve park management objectives and protection of natural systems and values (National Park Service, 2001). Recognizing that cooperation with other land managers can accomplish ecosystem stability and other resource management objectives when the best efforts of a single manager might fail, ANTI should develop agreements with other land managers when appropriate to coordinate natural resource management activities in ways to improve, not compromise, park resources. Communication and coordination with the Cooperative Extension Service, the Washington County Conservation District (WCCD), the Maryland Department of Agriculture (MDA), and the USDA Natural Resources Conservation Service (NRCS) are critical in managing and planning agricultural and conservation programs at ANTI (Wenschhof, 1997). These and other cooperating agencies are presented in Table 5.

A component of the tri-county Mid-Maryland Preservation Initiative is the 19,232-acre Washington County Rural Legacy Awards (RLA). The plan seeks to provide a buffer for the Antietam National Battlefield and its surrounding natural, cultural, and historic resources. The County was awarded $1.3 million to protect 662 acres within a RLA containing more than 6,000 acres of prime farmland. In FY 98/99 this RLA was awarded $1.8 million to preserve 700 acres. To date, more than 13,000 acres have been protected around ANTI and the town of Sharpsburg through state and federal efforts. This supplements recent efforts by the Maryland Departments of Natural Resources and Transportation, which together have invested $7.2 million to protect 3,000 acres around the battlefield (Maryland Department of Natural Resources, 1999).

ANTI has cooperated with the EPA Chesapeake Bay Program, implementing recommendations. A 1995 Federal Facilities Site Assessment at the battlefield, as part of the Chesapeake Bay Program, contributed to several management recommendations that are included in this report (i.e., nutrient management plans, limited cattle access to sensitive water resources, riparian restoration, designated public use areas along Antietam Creek, etc.) (Chesapeake Bay Program, 1995).

The Cooperative Conservation Initiative (CCI) is a funding source for ANTI to consider, especially for projects that contribute to protecting the Chesapeake Bay watershed. CCI projects include, but are not limited to, restoration, protection, or enhancement of natural areas. A $100 million CCI is proposed by the Department of the Interior, with the National Park Service's share being $72 million in State Grants ($50 million) and Challenge Cost Share ($22 million). More information on CCI can be obtained from the Department of Interior, Hugh Vickery at 202.501.4633 (Federal News, 2002).

The national Clean Water Initiative to restore and protect the streams, rivers, lakes, estuaries, and coastal bays of the United States has led to the development of Maryland's Clean Water Action Plan (Maryland Department of Natural Resources, 1998). This report describes Maryland's Unified Watershed Assessment, Watershed Restoration Priorities and the process under development to identify and implement Watershed Restoration

Table 5. Cooperating Agencies and Roles.

Washington County Soil Conservation District	Project sponsor and proponent. Responsible for implementation of the agricultural program aspects.
U.S.D.A. Natural Resources Conservation Service	Provide technical supervision for development of Soil Conservation and Water Quality Plans, and the installation of Best Management Practices (BMP) and systems.
Maryland Cooperative Extension Service	Has primary responsibility for the information and education programs for both rural and urban activities. Supervises the nutrient management programs.
Maryland Department of Agriculture	Assists Washington County Soil Conservation District, providing operating support, staff support, and cost-share funds for BMP installation.
Maryland Department of Environment	Responsible for providing technical and financial support for urban activities in addition to their regulatory and enforcement responsibilities.
Maryland Department of Natural Resources	Through its Forest Division and Wildlife Division, provides technical and financial assistance on some agricultural activities and on silvicultural activities.
U.S.D.A. Farm Services Agency	Provides financial assistance to landowners for installation of BMP's.
Washington County Health Department	Provides staff for technical assistance, regulatory and enforcement programs.
Washington County Commissioners	Through various departments, provides staff for technical assistance, regulatory, and enforcement programs for erosion/sediment control, and storm water management control programs.
U.S. Geological Survey/Maryland Geologic Survey	Has a network of stream monitoring stations and spring/well locations to monitor water quality and/or discharge.

Action Strategies. Maryland watersheds classified as *Category 1* "in need of restoration" are in violation of water quality standards, as reflected by inclusion on the 303(d) Impaired Waterbody List, and/or include poor values for other natural resource indicators. Pristine and high quality watersheds that need additional levels of protection are classified as *Category 3*. Watersheds sharing both *Category 1* Priority and Selected *Category 3* listings were identified as a high priority, which includes the Antietam drainage basin (Figure 11).

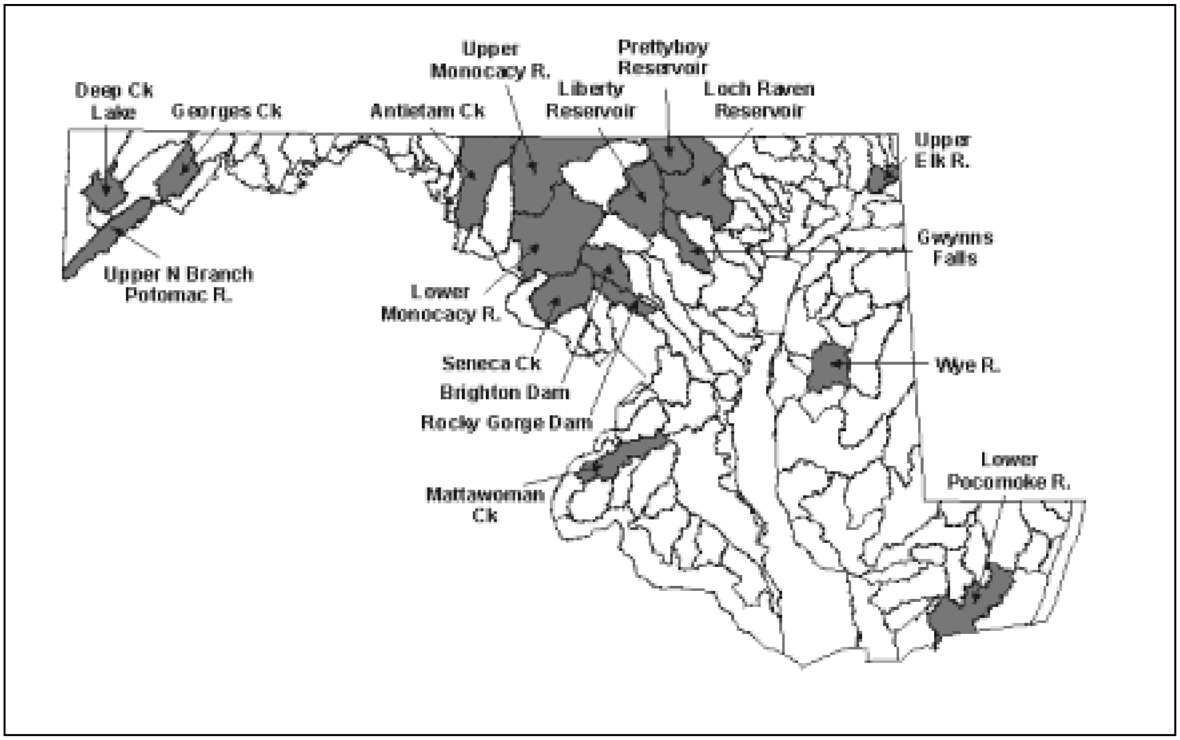


Figure 11. Maryland watersheds (shaded) sharing both *Category 1* Priority and Selected *Category 3* characteristics (Maryland Department of Natural Resources, 1998).

Maryland's long-term objective is to develop Watershed Restoration Action Strategies (WRAS) that are comprehensive, and address all aspects of watershed condition and water quality, including public health; aquatic living resources; physical habitat and the landscape. A WRAS will provide information and guidance that will help the public, watershed organizations, and federal, state and local agencies focus their staff and monies in areas and on issues important to the public and that will result in measurable environmental improvement.

The strategies may be drawn from existing assessment and targeting efforts such as a county's comprehensive plan, stormwater and sewer plans, capital budgets, greenways and open space plans, watershed stewardship programs, site design standards/BMPs, erosion and sediment control plans, soil conservation district watershed work plans and other efforts. A comprehensive strategy includes the following:

- A watershed-wide assessment of existing and anticipated future conditions that significantly affect water quality and natural resources. The assessment should identify the principal sources and relative contributions of point and nonpoint source pollution; major sources of habitat loss; and threats to drinking water; aquatic life, and natural resources critical to maintaining the integrity of the watershed.

- Measurable environmental and programmatic goals and a timeframe for achieving significant milestones/accomplishments.
- A public involvement process that provides mechanisms for informing the public and incorporating their concerns and priorities.
- A process for targeting individual projects for preventive or remedial activities (e.g. identifying appropriate areas to implement best management practices and buffer strips that will maximize the achievement of clean water and other natural resource goals.
- A water quality and natural resources monitoring element that utilizes existing and supplemental data sources to document current and future changes occurring in the watershed.
- A process to routinely evaluate the effectiveness of projects and/or systems and their progress toward achieving environmental and programmatic goals.

The potential benefits of this approach for Maryland's watersheds are significant. The results of this process will ultimately provide a comprehensive framework, which other programs can utilize to conduct coordinated activities on individual watershed issues. These benefits will only increase with the further evolution of the Clean Water Action Plan's Watershed Approach. Contact Dr. Paul Massicot, Maryland Department of Natural Resources, at 1.977.620.8367 (x 8682) for additional information on this effort.

Seeking support from local universities and other academic programs can provide local expertise to support natural resource management at ANTI. For example, to address riparian restoration issues at Burnside Bridge, ANTI successfully competed for funding in 2002 through the National Park Service's "Geoscientists-in-the-Parks" program. This will result in assistance through the *Association for Women Geoscientists* to evaluate the riparian issues at this location, providing recommendations to effectively remediate the problem(s).

Internal NPS coordination should also be considered by the park. For example, seeking technical assistance from the NPS-Air Resources Division for support in evaluating atmospheric deposition and associated water quality impacts, identifying air pollution-sensitive aquatic systems, and implementing air pollution-related water monitoring protocols, if warranted. Technical assistance is also available through the NPS Geological Resources Division and Water Resources Division.

In 1993, ANTI began work to establish the Antietam National Battlefield Water Watcher program, with funding from the National Park Foundation. This program is geared for students, grades 5 – 12. In this program, students and teachers are given a workbook and data sheet to guide their investigation. The 90-minute assignment includes testing specific water parameters in order to determine the stream's relative quality. The program challenges youth to think about the implications of water quality at the battlefield from many different perspectives.

RESOURCES MANAGEMENT STAFFING

The ANTI Resource Management Division staff is currently comprised of permanent positions as indicated in the organizational chart presented in Figure 12. Due to the lack of park staff, these positions must serve multiple disciplines at ANTI (i.e., resource management, safety, law enforcement). The Chief of Resource Management Division reports directly to the Superintendent. The Division of Natural Resources manages the natural elements of the cultural landscape and provides for protection of park resources and visitors. Responsibilities include air and water resources management, vegetation management, monitoring of fauna, agricultural leasing, integrated pest management, resource management planning, land resources, resource protection/law enforcement, health and safety.

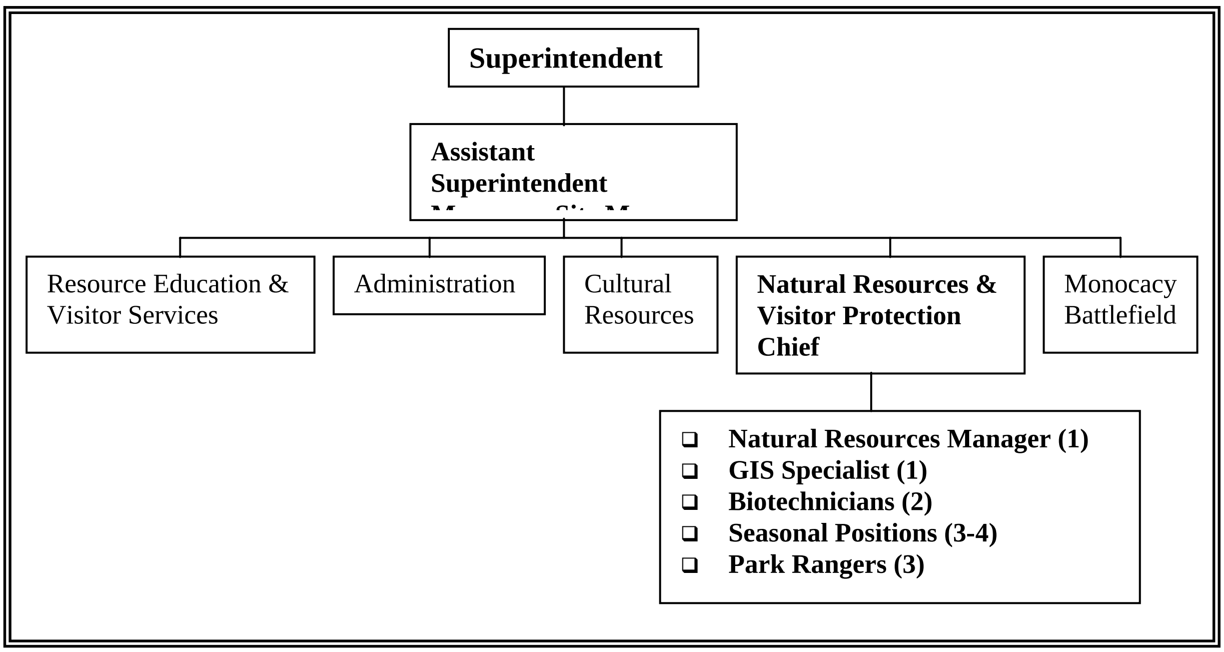


Figure 12. Antietam National Military Park, Natural Resources Management Program: Organizational Chart.

Active water-related efforts at ANTI include (Wenschhof, pers. comm., 2002):

- Riparian buffer establishment and maintenance
- Water quality monitoring springs and streams
- Water watchers program
- Agriculture management and cooperative planning
- Integrated Pest Management approach
- Sinkhole, well, and spring inventory
- Vital signs identification
- Funding request for karst research

RECOMMENDATIONS

The water-related issues and natural resource data presented in this report are supported, in part, through regional and local inventories, research, and monitoring efforts. Identification of available water resource information (i.e., what has or has not been done at ANTI) has also contributed toward exposing the "data gaps", which translates to natural resource needs for ANTI. A major issue for the natural resource management program at ANTI is the lack of direction due to gaps in natural resource baseline data. As a result, the present status of the park's natural resources, including water resources, is difficult to assess due to limited baseline information. ANTI should define, assemble, and synthesize baseline inventory data describing the park's water resources under its stewardship and should monitor key aspects of these resources, including interrelationships with visitor carrying capacities at regular intervals to detect changes that may require intervention, and to provide reference points for comparison with other environments and time frames. The collection of adequate information and data to support planning and the analysis of impact of environmental resources, including cultural resources, will precede any final decisions about the preservation or treatment of natural resources. The water-related needs captured in this report are summarized below:

- Baseline Inventory and Monitoring

    - All ground waters sampled in a 1997 survey at ANTI were ecologically impacted to some degree, primarily from agricultural practices. These waters showed excessive siltation and algae growth, indicative of elevated erosion rates and nutrient levels (Maryland Department of Natural Resources, 1997). The following steps have been recommended by the Maryland Department of Natural Resources (1997) to ensure the continued survival of ground water limited faunas within ANTI:

        1. Obtain baseline water quality data.
        2. Delineate the catchment basin.
        3. Minimize, and if possible, eliminate herbicide and pesticide use within the catchment basin.
        4. Minimize, and if possible, eliminate excessive nutrient input to the catchment basin.
        5. Restore natural flow regime, nutrient input, and erosion rates in the catchment basin.
        6. Monitor water quality.

    - Annual water resources reports are needed at ANTI to provide a timely understanding of the battlefield's water resource condition. This is important for park management and regional water and land managers (i.e., Maryland Department of Natural Resources, U.S. Geological Survey, Chesapeake Bay Watershed Program, etc.). These reports should capture the water quality and flow data collected within the battlefield's boundary by ANTI, the Maryland Department of Natural Resources, and the U.S. Geological Survey, including climate data (i.e., precipitation). Historical water quality data presented in the *Baseline Water Quality Inventory and Analysis, Antietam National Battlefield* (National Park Service, 1995) could serve as the foundation for this effort. In order to produce an annual summary report that is most useful to management and provides adequate monitoring of potential anomalies and long-term trends, a standardized format should be used to record, list, and display all data. All data should be graphically plotted on a yearly basis, showing extreme values (maximum & minimum), median values, 25th and 75th percentiles, via box and whiskers graphics. The following graphs should be considered for the standardized format:

1. Yearly trends (one box & whiskers graph representing one years data) for each site.
2. Yearly tends for each parameter for all monitoring stations combined.
3. A yearly comparison of differences between sites (one box & whiskers graph representing one site).
4. A yearly comparison of each month's data for each parameter (one box & whiskers graph representing one months data).

- Martinsburg, WV and Hagerstown, MD are the closest meteorological monitoring stations to the battlefield, thus a weather station at ANTI is warranted to correlate local weather influences on water chemistry and flow dynamics (note: a fire weather station is planned at ANTI).

- In 1994, the U.S. Geological Survey evaluated the occurrence of herbicides in surface water in the Potomac River Basin, including Antietam Creek. Antietam Creek had detectable concentrations of atrazine (0.300 μg/L), simazine (0.083 μg/L), metolachlor (0.088 μg/L), and prometon (0.063 μg/L). Additional study is needed to verify apparent relations between cropland and orchards and herbicide concentrations in streams (U.S. Geological Survey, 1995).

- ANTI has a well-maintained GIS database. The current GIS data themes include; soils, roads, surface hydrology, topography, hedgerows and field borders, legislative park boundary, scenic easements, and private land tracts. The park's GIS program is working to incorporate additional GIS data layers, along with new park-specific themes (i.e., wetlands, floodplains, riparian buffer restoration) to help fuel some of the park's management needs for natural resources. ANTI should inventory what GIS data sources exist externally before working to generate new park-specific data themes. For example, Duigon (2001) contains some excellent hydrogeology, hydrology, and karst inventory maps (e.g., drainage basins, potentiometric surface, spring inventory, ground water well inventory, karst features, etc.) of Washington County, including the battlefield, that could be digitized into ANTI's GIS database. GIS hydrography for ANTI can also be obtained through the NPS

Water Resources Division (Water Operations Branch: Dean Tucker at 970.225.3516).

- Impacts to Antietam Creek are being documented in the freshwater mussel community. Mussels are extremely sensitive to change in stream water quality due to siltation, heavy metals, sewage effluent, and pesticides. Recent surveys indicate that freshwater mussels are currently in decline in Antietam Creek (Maryland Department of Natural Resources, 1997). These surveys should continue as best management practices (BMPs) are employed, to evaluate effectiveness of management actions and document species recovery at ANTI.

- A previously undescribed species of sculpin was found to be widely distributed and abundant in Antietam Creek and its tributaries during a 1992 survey (Reasly, 1992). According to the Maryland Department of Natural Resources (1997), ongoing monitoring of the sculpin should take place and preservation/restoration of riparian habitat is crucial.

- Riparian Restoration

  - At several locations along Antietam Creek and its tributaries, stream banks are unnaturally undercut and eroding. These locations are typically void of native woody vegetation due to visitor impacts in high-use areas. During the summer, recreationalists canoe, fish and tube float down Antietam Creek. If this is an appropriate recreational activity in ANTI, controlled access points should be developed.

  - Several natural resource issues need to be addressed at the Burnside Bridge location. A concrete and rock drainage parallels a walkway on the west side of the creek, before discharging runoff onto a steep slope several hundred feet down to Antietam Creek. This concentrated discharge has resulted in excessive erosion of the slope and produced a debris fan of sediments and rock in Antietam Creek below. Small dams and velocity/energy dissipaters have been recommended for construction along the path of concentrated flow. This particular reach of the creek has little to no riparian vegetation due to an interpretive trail, Snavely Ford Trail, located on the stream bank and, as previously described, heavy visitor use. It has been speculated that the lack of riparian vegetation at this location and increased stream discharge associated with upstream development outside ANTI contributes to the bank instability and excessive erosion. With assistance from the NPS-Water Resources Division, ANTI successfully competed for funding in 2002 through the National Park Service's "Geoscientists-in-the-Parks" program. This will result in assistance through the *Association of Women Geoscientists* to evaluate the riparian issues at this location, providing recommendations to remediate the problem(s).

- The Maryland Department of Natural Resources (1997) recommends: 1) working with neighbors and farm leases to maintain buffer along wetlands and streams, including gullies and swales; 2) avoid mowing stream side vegetation; and 3) increase riparian buffer anywhere it does not conflict with historic interpretation (streamside trails should allow at least 15 meters of riparian buffer, where possible).

- Continue implementation of Chesapeake Bay Riparian Forest Buffer Systems (RFBS) as Best Management Practices (BMPs) at ANTI. ANTI has already established 4,455 feet of riparian buffer within the battlefield's boundary.

- Continue to survey for sculpin and freshwater mussels in ANTI to evaluate riparian restoration efforts in the battlefield.

- Agricultural Management

  - Rotate crops to reduce soil erosion, improve soil fertility, and disrupt life cycles of weeds, insects, and diseases.

  - In crop areas, establish a 25-30 foot buffer of native grasses, shrubs, and trees or as historic scene restoration requires.

  - Encourage conservation tillage (30% residue coverage) or no tillage to protect highly erodible soils. Contour tillage or strip cropping are also appropriate farming techniques.

  - The NPS Integrated Pest Management staff should be involved in pesticide selection and use.

  - Application of pesticides and fertilizers should be recorded.

  - Nutrient management plans should be approved and implemented for all agricultural activities in ANTI.

- Wastewater Treatment

  - ANTI should review, and if appropriate, upgrade to new sewage treatment technology. High levels of bacteria have been found in springs throughout the battlefield (Antietam National Battlefield, 1999). The elevated bacteria concentrations may be related to pre-1988 conditions or from individual septic systems at homes surrounding the battlefield. Central sewage treatment for Sharpsburg was not completed until 1988. About 40% of Washington County's population use some sort of private sewage system. The most widely used system is the conventional septic system with the cement or fiberglass holding tank and a drainage field (Washington County-Maryland, 2001). In areas like ANTI where the bedrock is shallow or water tables are high, other types of systems such as a mound and sand filter systems may be more appropriate. One of the newest varieties of septic system is the denitrification system.

- Ground Water Wells and Springs

    - Defining the sensitive recharge areas and ground water flows for karst aquifers underlying the battlefield is needed. Delineation of a catchment basin in karst geology is typically approached through dye tracing techniques due to the unpredictable nature of carbonate hydrogeology. If there are several small aquifers in the area, this increases the complexity of ground water flow, and validates the need for dye tracing, in concert with other tools (e.g., potentiometric surface maps, ground water chemistry, etc), to confirm flow paths.

    - There are a number of ground water wells and springs at the battlefield. Wells that are no longer in use should be considered for plugging and abandonment (following state-approved methodologies) since they provide a pathway for contaminants to enter the shallow karst aquifers at ANTI. Some of these inactive wells may have value for future ground water monitoring or research projects, if so, they should be properly protected from surface influences. Chemical applications to crops and animal wastes from grazing livestock (cattle) at the battlefield are concerns for both wells and springs.

    - Two possible sinkholes on the Poffenberger Farm, located at the West Woods reforestation area north of Confederate Avenue, were observed to be full of trash (Wenschhof, 1997). Unfortunately, this practice is common in karst landscapes, where sinkholes appear to be an appropriate place to dispose of unwanted materials. These areas are important recharge locations for the local aquifers. ANTI should identify and clean areas where trash is being illegally dumped (i.e., sinkholes) to minimize contamination of the groundwater aquifers. At the same time, park staff should work toward educating the public through various media on the importance of properly managing waste in karst landscapes. If people understand that they are damaging their water supply, it typically results in immediate compliance.

- Hazardous Waste Management and Spill Contingency Planning

    - Educate staff as needed on procedures and information outlined in ANTI's Oil Spill Prevention and Response Plan (Ecology and Environment Inc., 2001).

    - Produce a HazMap for ANTI that identifies flow paths for existing drainage structures and hydrologic features to assist emergency spill responders (note: this effort should take place after delineation of ground water flow through dye tracing.).

- According to ANTI's compliance audit report (Prizim Inc., 2002), park personnel demonstrated a good understanding of environmental regulatory knowledge and showed initiative in protecting the environment. The following recommendation summary was developed from compliance deficiencies cited during the audit site-visit:

    1. Formalize a document control system for environmental and health system management;
    2. Formalize environmental health and safety programs;
    3. Improve housekeeping, related to hazardous material storage and waste management; and
    4. Improve working conditions to reduce common hazards, including proper guards, improve working walking surfaces, and ensure exits are properly marked.

- The Resource Conservation and Recovery Act (RCRA), as amended by the Hazardous and Solid Waste Act Amendments of 1984 and Title III of the Superfund Amendment Reauthorization Act (SARA Title III) require hazardous waste reduction programs. Executive Order 12873 establishes the goal for federal agencies to reduce their input into the waste stream by 40%. ANTI should implement or improve waste reduction programs through recycling efforts that are applicable to both park staff and visitors.

❑ Wetlands Management

- Survey the Poffenberger Farm, Roulette Farm, and Mumma Farm for potential wetlands to update ANTI's existing wetlands database generated from the National Wetland Inventory (NWI) maps (1:24,000) and the 1990 wetlands survey completed for the General Management Plan (National Park Service, 1990).

❑ Coordination

- Continue cooperative farming efforts and employment of best management practices as described under *Agricultural Management*.

- Work cooperatively with the agencies presented in Table 5.

- Seek funding for restoration, protection, and enhancement projects for natural areas through the Cooperative Conservation Initiative.

- Stay informed and become involved, where appropriate, on Watershed Restoration Action Strategies for the Antietam Creek drainage basin as defined in Maryland's Clean Water Action Plan.

- Seek support from local universities and other academic programs for water-related projects (i.e., Geoscientists-in-the-Parks).

- Seek technical assistance, as needed, from the NPS Water Resources Division, Air Resources Division, and Geological Resources Division in Colorado.

- Continue to provide water-related educational opportunities for local youth through the Antietam National Battlefield Water Watcher program.

Based upon ANTI's water resources and associated issues, this Water Resources Scoping Report will meet the park's water resource management needs over the next several years. Components of this scoping report should be used in the development of time-sensitive management strategies and priority project statements relating to park-specific water resource issues. The park is encouraged to work through the NPS technical assistance process, or with other agencies (i.e., USGS, ICPRB, MDNR), as needed, to prepare discipline-specific project statements to compete for internal and/or external funding sources.

LITERATURE CITED

Antietam National Battlefield, 1999. Water Quality Monitoring Plan. Sharpsburg, MD.

Ator, S.W., J.D. Blomquist, J.W. Brakebill, J.M. Denis, M.J. Ferrari, C.V. Miller, and H. Zappia. 1998. Water Quality in the Potomac River Basin, Maryland, Pennsylvania, Virginia, West Virginia, and the District of Columbia, 1992-96: U.S. Geological Survey Circular 1166. Baltimore, MD. 38 pp.

Belval, D.L. and L.A. Sprague. 1999. Monitoring Nutrients in the Major Rivers Draining to Chesapeake Bay. Water-Resources Investigations Report 99-4238. Richmond, VA. 14 pp.

Burke, T.A., J.S. Litt, and M.A. Fox. 1999. Linking Public Health and the Health of the Chesapeake Bay. John Hopkins School of Hygiene and Public Health, Baltimore, MD. [In} Environmental Research Section A 82:143-149.

Bolton, D.W. 2001. Mumma Spring (WA Di 103) Water Quality Data, 1990-2000. Maryland Department of Natural Resources. Maryland Geological Survey. Baltimore, MD.

Chesapeake Bay Program. 1995. Federal Facility Site Assessment: Antietam National Battlefield. Annapolis, MD. 8 pp.

Cohen, D. 2002. Personal Communication. Antietam National Battlefield. Sharpsburg, MD.

Cowardin, L.M., V. Carter, F.C. Golet, and E.T. LaRoe. 1979. Classification of Wetlands and Deepwater Habitats of the United States. U.S. Dept. Interior – Fish and Wildlife Service, FWS/OBS-79/31.

Duigon, M.T. 1997. A brief discussion of the Project, “Karst Hydrogeology in the Hagerstown Valley, Maryland and its Influence on Ground-Water-Quality Protection”. Maryland Geologic Survey. Baltimore, MD. 2 pp.

Duigon, M.T. 2001. Karst Hydrogeology of the Hagerstown Valley, Maryland. Report of Investigations No. 73. Maryland Geologic Survey. Baltimore, MD. 128 pp.

Duigon, M.T. 2002. Karst Hydrogeology of the Hagerstown Valley, Maryland (abstract). Maryland Geologic Survey. Baltimore, MD. 1 p.

Ecology and Environment, Inc. 2001. Oil Spill Prevention and Response Plan, Antietam National Battlefield. Contract No.: GS-10F-0160J, GSA Schedule 899, SIN899-4. Washington DC.

Federal News. 2002. Questions and Answers on the Cooperative Conservation Initiative, January 31, 2002. http://www.waterchat.com/News/Federal/02/Q1/fed_020206-02.htm.

Fry, J.F. and J. Meiman. 1994. The Development of a Karst Groundwater Hazardous Spill Map within the Drainage Basins of Mammoth Cave. Mammoth Cave National Park, Mammoth Cave, KY. 10 pp.

Hagerstown-Washington County Economic Development Commission. 2001. Demographic Profile of Washington County-2000. http://www.hagerstownedc.org/Demographics/demo.html

Hobba, W.A., Jr., E.A. Friel, and J.L Chisholm. 1972. Water Resources of the Potomac River Basin, West Virginia. River Basin Bulletin 3. U.S. Geological Survey, Water Resources Division. 110 pp.

Interstate Commission on the Potomac River Basin. 2002. Potomac River Reporter. Hagerstown Discharge Sparks ICPRB Action. vol. 58, no. 1.

Karr, J.R., and I.J. Schlosser. 1978. Water Resources and the Land-Water Interface. Science 201:229-234.

Kemble, J. and E. Wenschhof. 1995. Antietam National Battlefield Resources Management Plan. Sharpsburg, MD.

Lowrance, R., R. Leonard, and J. Sheridan. 1985. Managing Riparian Ecosystems to Control Nonpoint Pollution. Jour. Soils and Water Cons. 40:87-91.

Lowrance, R., L.S. Altier, J.D. Newbold, R.R. Schnabel, P.M. Groffman, J.M. Denver, D.L. Correll, J.W. Gilliam, J.L. Robinson, R.B. Brinsfield, K.W. Staver, W. Lucas, and A.H. Todd. 1995. Water Quality Functions of Riparian Forest Buffer Systems in Chesapeake Bay Watershed. Nutrient Subcommittee of the Chesapeake Bay Program. EPA 903-R-95-004. 67 pp.

Maniero, T. 2002. Personal Communication. National Park Service – Air Resources Division. Rochester, NY.

Maryland Department of Natural Resources. 1997. Antietam National Battlefield. Natural Areas Inventory for Rare, Threatened and Endangered Plants and Selected Animals with Management Recommendations. Heritage & Biodiversity Conservation Programs. Annapolis, MD. 39 pp. + appendices.

Maryland Department of Natural Resources. 1998. Maryland Clean Water Action Plan Final 1998 Report on Unified Watershed Assessment, Watershed Prioritization and Plans for Restoration Strategies. Maryland Clean Water Action Plan Technical Workgroup.

Maryland Department of Natural Resources. 1999. 1999 Maryland's Rural Legacy Awards. http://www.dnr.state.md.us/rurallegacy/rlnews/99awards.html.

Maryland Geologic Survey. 1968. Geologic Map of Maryland. Maryland Department of Natural Resources. Baltimore, MD.

Millard, C.J., P.F. Kazyak, and A.P. Prochaska. 2001. Washington County. Results of the 1994-1997 Maryland Biological Stream Survey: County-Level Assessments. Maryland Department of Natural Resources, Resources Assessment Service, Monitoring and Non-Tidal Assessment Division. Annapolis, MD. 32 pp. + appendices.

Naiman, R.J. and H. Décamps. 1997. The Ecology of Interfaces; Riparian Zones. University of Washington, School of Fisheries, Seattle, Washington, Annu. Rev. Ecol. Syst. 1997. 28:621-58.

National Climate and Data Center. 2002. 1961-1990 Climatic Data for Martinsburg, West Virginia. NCDC TD 9641 Clim 81 1961-1990 Normals. <URL:http//www. worldclimate.com/cgi-bin/data.pl?ref=N39W077+1300+ 465707C, 1302+465707C, 1304+465707C, 2300+465707C>

National Park Service, 1990. Wetlands Survey of Antietam National Battlefield. Internal memorandum from Manager, Eastern Team, Denver Service Center to Regional Director, National Capital Region.

National Park Service, 1991. NPS-77, Natural Resources Management Guideline. Natural Resources Division, NPS. Washington, D.C.

National Park Service, 1992. General Management Plan/Final Environmental Impact Statement: Antietam National Battlefield. Washington, D.C. 208 pp.

National Park Service, 1995. Baseline Water Quality Data, Inventory and Analysis, Antietam National Battlefield. Water Resources Division and Servicewide Inventory and Monitoring Program. Ft. Collins, CO. 308 pp. + appendices.

National Park Service. 1995a. The Potomac River Watershed: A National Resource. An Assessment of Significant Natural, Cultural, and Recreational Resources (Draft). NPS - Mid-Atlantic Regional Office, Division of Park and Resource Planning. Philadelphia, PA. 51 pp.

National Park Service. 1995b. Baseline Water Quality Data, Inventory and Analysis, Antietam National Battlefield. Water Resources Division and Servicewide Inventory and Monitoring Program. Ft. Collins, CO. 308 pp. + appendices.

National Park Service. 1996. Resources Management Plan, Chesapeake and Ohio Canal National Historic Park. Sharpsburg, MD.

National Park Service. 1998a. National Park Service Procedural Manual 77-1: Wetland Protection, Technical Report NPS/NRWRD/NRTR/-98-203. NPS, Water Resources Division. Ft. Collins, CO. 32 pp.

National Park Service. 1998b. The National Park Service Chesapeake Bay Riparian Buffer Plan. NPS-Northeast Region. Philadelphia, PA. 39 pp.

National Park Service. 2001. National Park Service, Management Policies. Washington D.C. Ch. 4.

Norris, M. 2002. Personal Communication. Hydrologist, National Park Service, National Capital Region. The Center for Urban Ecology. Washington D.C.

Prizim Inc. 2002. (Draft) Compliance Assistance Project Audit of Antietam National Battlefield. Contract No. GS-10F-0234L, Order No. P3000010596. Olde Town Gaithersburg, MD. 41 pp.

Reasly, R.L. 1992. Distributional Status of *Cottus* species in Antietam Creek, Maryland. Frostburg State University, Department of Biology. Frostburg, MD.

Snell, C.W. and S.A. Brown. 1986. Antietam National Battlefield and National Cemetery, An Administrative History. National Park Service. Washington, D.C.

Stahlnecker, K. 1987. Surface Water Quality Monitoring Plan, Antietam National Battlefield, February 1987. National Park Service, Antietam National Battlefield. Sharpsburg, MD. 8 pp.

U.S. Army Corps of Engineers, 1972. Antietam Creek Floodplain Information. Washington County, Maryland. Baltimore District.

U.S. Environmental Protection Agency, 2002. Maryland 303(d) Listed Waters in the Conococheague-Opequon Watershed. http://www.epa.gov/iwi/303d/02070004_303d.html.

U.S. Fish and Wildlife Service, 2002. National Wetlands Inventory Map of Antietam. http://ecos.fws.gov/nwi_mapplet/summap.html.

U.S. Geological Survey, 1995. Selected herbicides in major streams in the Potomac River basin upstream from Washington, D.C. NAWQA Fact Sheet 107-95. Townson, MD. 4 pp.

Washington County, Maryland. 2001. Draft Comprehensive Plan for the County 2001. 318 pp.

Washington County Soil Conservation District. 2000. The Antietam Creek Targeted Watershed Project. http://www.mda.state.md.us/wash/Antcrk.htm. Hagerstown, MD.

Wenschhof, E.R., Jr. 1997. Identification of Sensitive Soil and Water Resources and Evaluation of Agricultural Conservation Practices at Antietam National Battlefield, Sharpsburg, Maryland (unpubl. Master thesis). Shippensburg University. Shippensburg, Pennsylvania. 97 pp. + appendices.

Wenschhof, E.R., Jr. 2002. Personal communication. Antietam National Park Service Battlefield. Sharpsburg, MD.

White, W.R. 1997. Military Geology: Antietam Battlefield. http://www.howard.k12. md.us/white/AntietamFT.html.

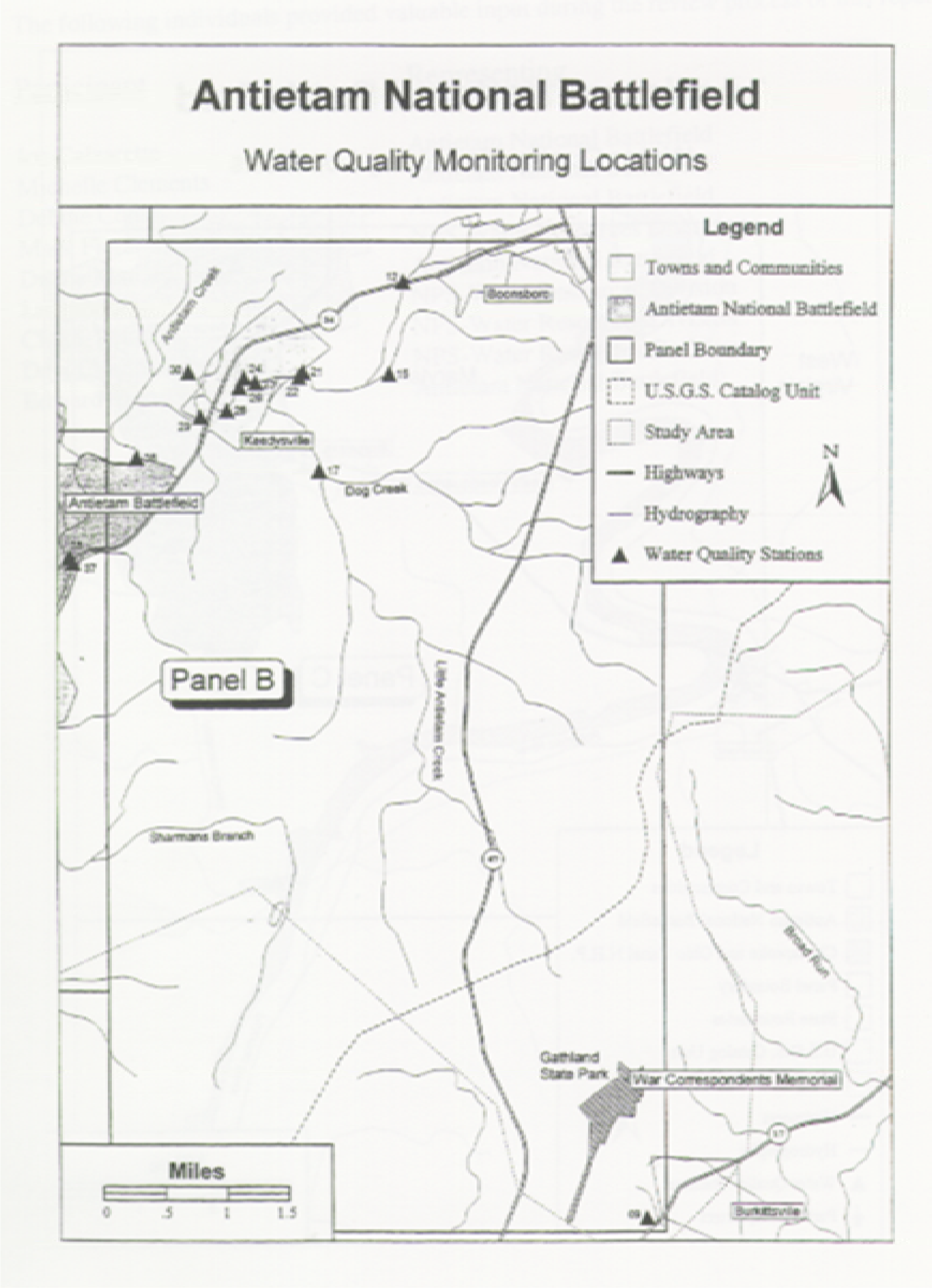
William & Mary. 2000. The Geology of Virginia. The College of William and Mary, Williamsburg, Virginia. <URL:http//www.wm.edu/cas/geology/ virginia/ coastal_plain.html, piedmont.html, blue_ridge.html, valley_ridge.html, coastal_plain.html>

APPENDIX A. Calendar year streamflow for Antietam Creek.

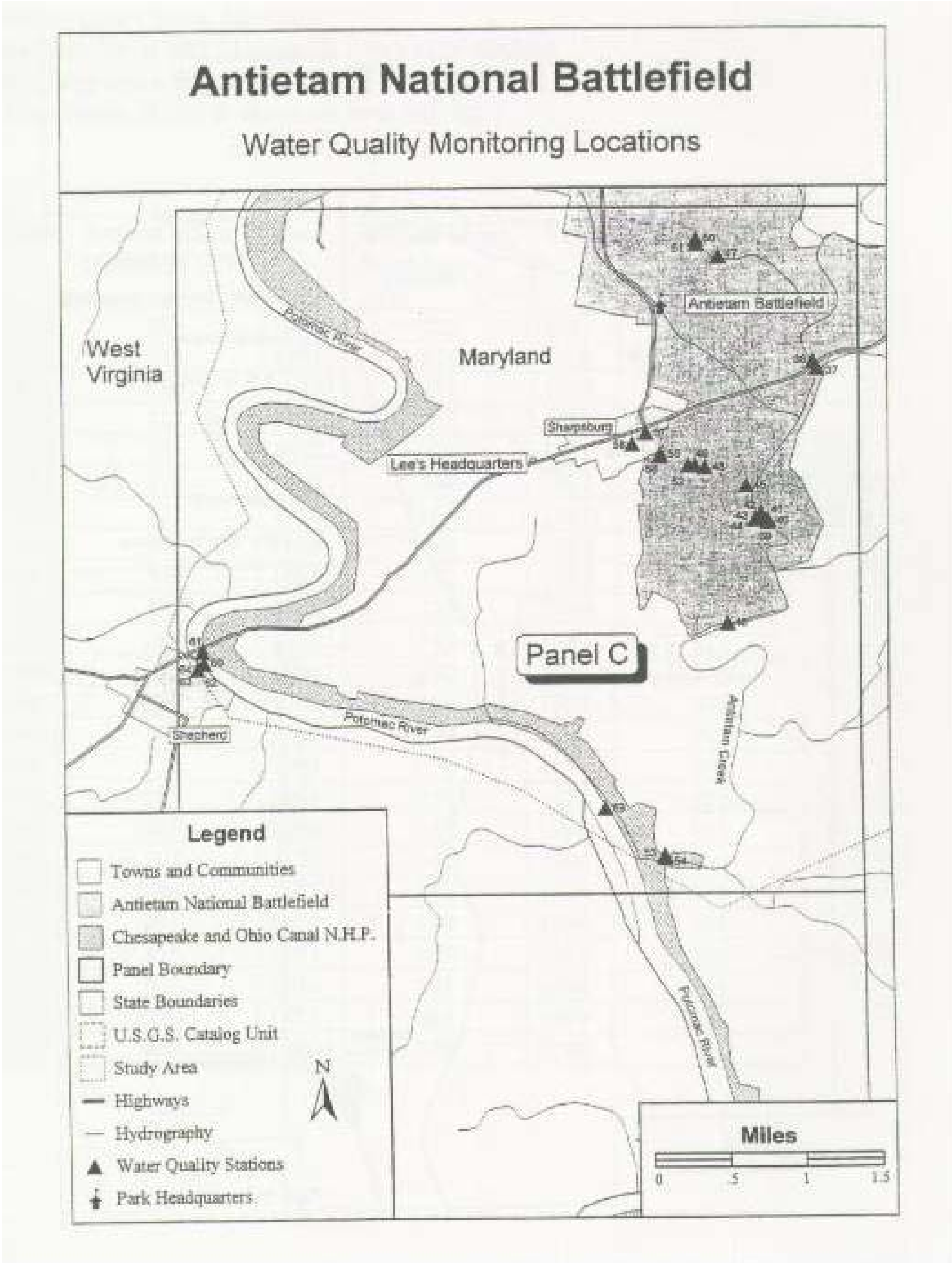
USGS Station 01619500: Antietam Creek near Sharpsburg, MD.
Washington County, Maryland
Latitude 39°26'59.2", Longitude 77°43'48.7" NAD83
Drainage area = 281 mi^2
Gage datum 311.05 ft. above sea level NGVD29

Year	Annual Mean Discharge (cfs)	Year	Annual Mean Discharge (cfs)	Year	Annual Mean Discharge (cfs)
1929	297	1953	326	1977	264
1930	183	1954	134	1978	346
1931	120	1955	251	1979	461
1932	217	1956	301	1980	273
1933	321	1957	220	1981	196
1934	178	1958	309	1982	268
1935	233	1959	153	1983	329
1936	342	1960	226	1984	458
1937	376	1961	277	1985	252
1938	172	1962	222	1986	247
1939	246	1963	187	1987	227
1940	335	1964	230	1988	205
1941	207	1965	154	1989	241
1942	321	1966	140	1990	250
1943	279	1967	276	1991	258
1944	187	1968	256	1992	301
1945	262	1969	132	1993	453
1946	227	1970	341	1994	430
1947	188	1971	346	1995	212
1948	271	1972	510	1996	703
1949	355	1973	402	1997	286
1950	338	1974	303	1998	503
1951	350	1975	563	1999	182
1952	429	1976	378	2000	258

APPENDIX B. Water Quality Monitoring Location Map for Antietam National Battlefield.



APPENDIX B (continued). Water Quality Monitoring Location Map for Antietam National Battlefield.



Appendix C. List of Reviewers

The following individuals provided valuable input during the review process of this report.

Participant	Representing
Joe Calzarette	Antietam National Battlefield
Michelle Clements	Antietam National Battlefield
Debbie Cohen	Antietam National Battlefield
Mark Flora	NPS-Water Resources Division
Duane Marcus	Antietam National Battlefield
Larry Martin	NPS-Water Resources Division
Chuck Pettee	NPS-Water Resources Division
David Vana-Miller	NPS-Water Resources Division
Edward Wenschhof	Antietam National Battlefield

As the nation's principal conservation agency, the Department of the Interior has responsibility for most of our nationally owned public lands and natural resources. This includes fostering sound use of our land and water resources; protecting our fish, wildlife, and biological diversity; preserving the environmental and cultural values of our national parks and historical places; and providing for the enjoyment of life through outdoor recreation. The department assesses our energy and mineral resources and works to ensure that their development is in the best interests of all our people by encouraging stewardship and citizen participation in their care. The department also has a major responsibility for American Indian reservation communities and for people who live in island territories under U.S. administration.

NPS D-85, July 2002